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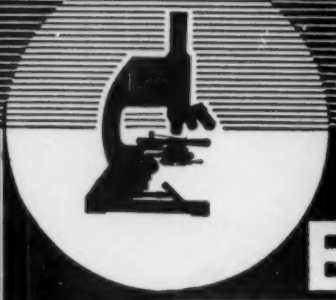


SCIENCE EDUCATION

THE SCIENCE MAGAZINE FOR ALL SCIENCE TEACHERS
FORMERLY GENERAL SCIENCE QUARTERLY

Results of a Test on Scientific Thinking

A Study of Bacteria in Grade Five

Survey of Generalized Science Courses

Experimental Comparison of Two Methods in Teaching Chemistry

Teaching Photosynthesis

Determination of Science Instructional Materials in Teachers Colleges

Effect of Shortened Class Periods Upon Achievement in Physics

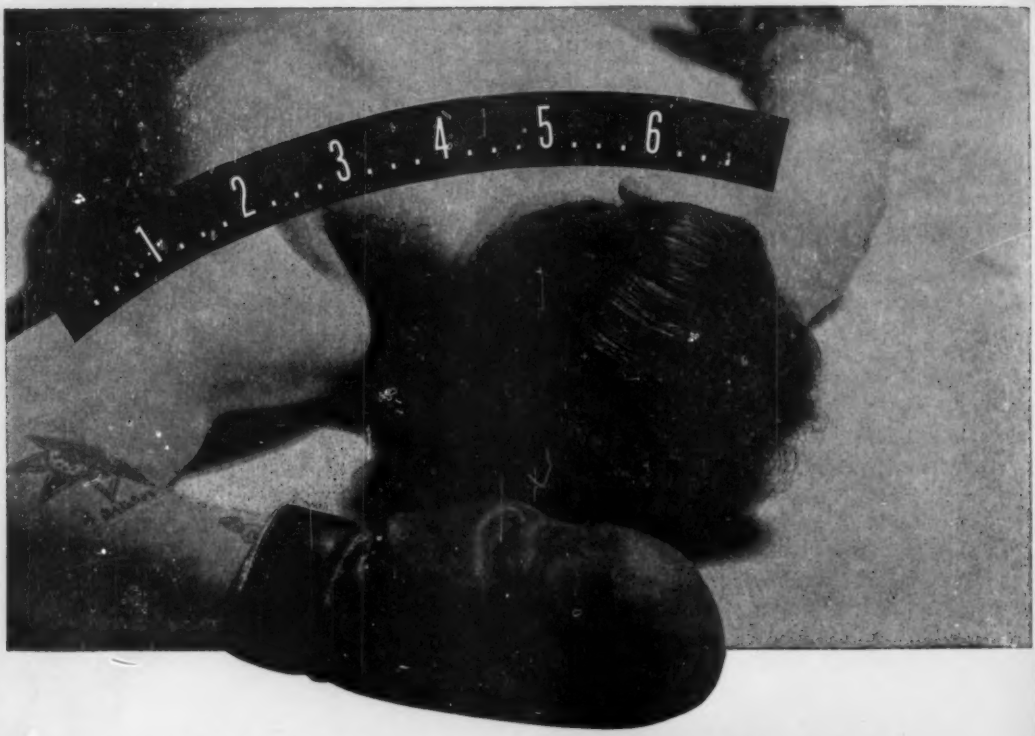
Building a Nature Trail

Home-Made Fire Alarm

Group Project in Refraction

Movable Diagrams in General Science

VOLUME 20
NUMBER 3
OCTOBER 1936



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Science Education

Formerly GENERAL SCIENCE QUARTERLY

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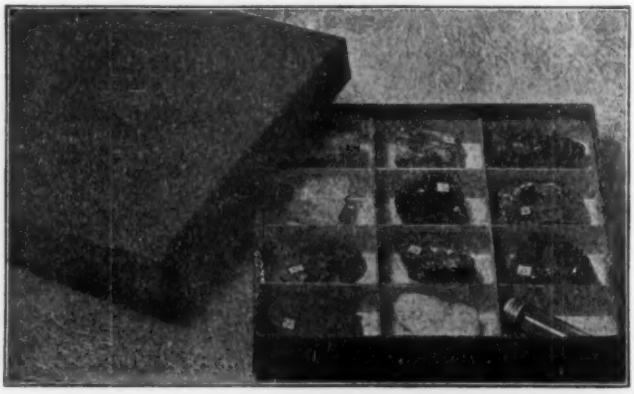

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Volume 20 OCTOBER, 1936 Number 3

SOME RESULTS OF A TEST ON SCIENTIFIC THINKING

ELLIOT R. DOWNING
Williams Bay, Wisconsin

The published works of the great scientists, the biographies, journals and letters of such men are all exceedingly valuable sources of objective evidence as to how the mind of the scientist works—the method of science. The latter materials are often of more value than the former for in his published works the end results are given while in journals and letters to friends, written when the work is hot on the anvil, the investigator gives details of procedure, analyzes his successes and his failures to determine their causes. So one can see not only what are the successive steps in the scientific method of thinking but also the hazards encountered, the places at which investigators have been most liable to make missteps. It is possible then to list the safeguards that need to be observed at each step to insure correct conclusions in the thought processes.

On the basis of such studies the author has ventured to present a list of the elements of scientific thinking and of the safeguards needed as each element comes into use.[1] Then there was devised a test to measure skill in the use of some of these elements and safeguards. To attempt to cover all in a single test made it too long to administer at a single sitting. It seems desirable to publish the results of this test to serve as a basis for the formulation of better tests along this line.

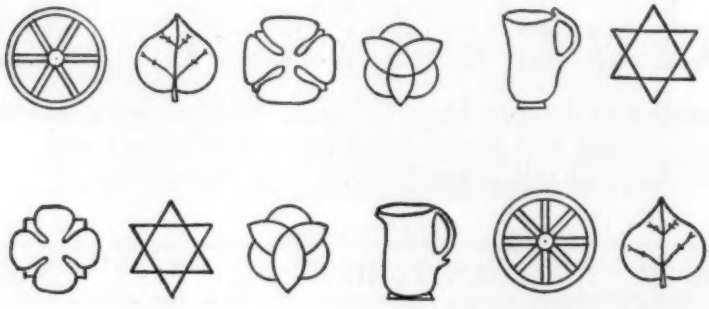
The test follows together with the directions for giving and scoring it. In the latter there is also stated what each item is designed to test.

[1] Downing, E. R. "Elements and Safeguards of Scientific Thinking." *The Scientific Monthly* 26: 231–243; May, 1928 (Also see Chapter IV in *An Introduction to the Teaching of Science,* The University of Chicago Press, 1934).

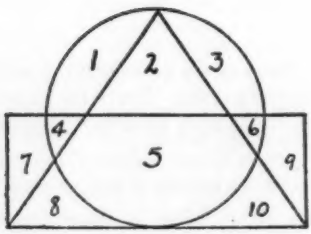
Name_____ Grade_____ Age_____

School_____ Date_____

1. If a figure in the upper row has one just like it in the lower row, join the two by a line. Do the same for all such pairs.



2.



Write the numbers in the figure at the left that

1. Are in the rectangle only_____.
2. Are in the circle only_____.
3. Are in all three figures_____.
4. Are in the triangle only_____.
5. Are only in both the rectangle and circle_____.

3. Write all the words you can make by combinations of any or all the letters of "Owen." Do not use any letter more than once in the same word.

_____ _____ _____ _____ _____ _____

_____ _____ _____ _____ _____ _____

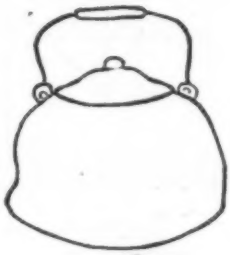
_____ _____ _____ _____ _____ _____

_____ _____ _____ _____ _____ _____

_____ _____ _____ _____ _____ _____

4. Each of these pictures has something missing. You are to draw in with your pencil the missing part.

Example. Here is a rabbit with only one ear. You would put on the other ear.

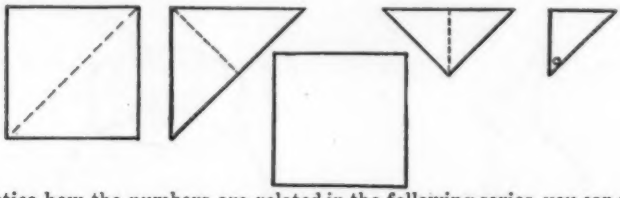


5. A boy sits alone in a boat in the middle of a pond. He looks repeatedly over the sides, meanwhile crying bitterly. Give all the suggestions you can in regard to what may have happened.

---

6. Two trucks start out together from the same place on the same straight road. The one ton truck is driven twenty miles per hour, the five ton truck thirty miles. If, ten minutes after the start, the former hits the latter, which will probably be damaged most by the collision?

7. A paper is folded three times along the dotted line as shown in the figures below. A hole is then punched through the several thicknesses of paper at the point shown by the little circle. Show on the blank square by drawing little circles where these holes will appear when the paper is unfolded.



8. If you notice how the numbers are related in the following series, you can write the next numbers in the series in the blank spaces provided. Please do so.

2, 3, 5, 8, 12, ---, ---

1, 4, 10, 28, 76, ---, ---

1, 5, 9, 13, ---, ---

$\frac{2}{3}$ $\frac{3}{4}$ $\frac{4}{6}$ $\frac{6}{8}$ $\frac{8}{12}$ ---, ---

9. Check the conclusion below which should be drawn from the following facts:

A. Recently several cases of typhoid fever broke out among the students in a western college.

B. The milkman who supplied the college dining room with milk also carried milk to many homes in the city.

C. Typhoid fever is caused by a tiny living germ.

D. The well on the campus was a shallow one only ten feet deep.

E. All the students who were sick took their meals at the college dining room.

F. Typhoid is a disease of the intestines, the discharge from which in one who is sick with the disease contains millions of germs.

G. The germs of typhoid fever usually get into one on raw vegetables that are eaten or in the milk or water one drinks.

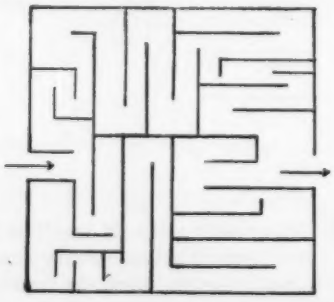
H. The vegetables for the college were supplied by one of the large grocery stores of the town.

Conclusion.

1. The germs of typhoid fever were in the milk.
2. The water from the well likely carried the germs.
3. The data are insufficient. No conclusions can be drawn as to the source of the infection.
4. The vegetables served to the students carried the typhoid infection.

10.

Put your pencil point at the head of the left-hand entering arrow and trace the path your pencil will take to come out at the right-hand arrow. The pencil point must not cross any line. Do not make any erasures.



11. If you care to express an opinion on the following, mark each one that is true with a T and each that is untrue with a W.

A. The prohibition amendment should be re-enacted to reduce intemperance.

B. Fossil remains, the evidence from embryology and from geographical distribution of plants and animals prove the theory of evolution.

C. Laborers are seldom given a square deal by their employers.

12. Cross out each 4 in the following list of numbers if the sum of the two numbers that precede it is greater than 4, but do not cross the 4 out if it is followed by a 7.

3 4 8 2 9 6 3 7 8 9 2 3 4 2 8 3 7 6 4 7 5 4 3 9 6 4 8 5
2 6 7 1 2 4 5 9 6 2 4 7 1 9 7 2 4 5 6 3 2 2 4 5 4 7 1 2
4 5 5 7 1 2 3 8 1 4 9 3 2 6 4 7 8 2 1 7 4 5 7 9 2 8 4

How many 4's have you crossed out?_____

13. Which of these lines is the longer—the dotted one or the solid one?

_____

14. If the conclusion follows from the data given, put a check in front of the statement.

A. A block of wood floats in the ocean. It will therefore float in Lake Michigan.

B. A body falls 16 feet in the first second. It will therefore fall 32 feet in the first two seconds.

C. Rubber stretches easily and is an elastic material. Steel does not stretch easily and therefore it is not an elastic material.

D. Chlorophyll is a substance necessary in order that a plant may make its own food. Musrhooms contain no chlorophyll. Therefore mushrooms do not make their own food.

15. Write these sentences in the space below in the order that makes it easiest for you to see which word, heavier or lighter, is to be written in the conclusion.

A. Iron is heavier than sodium.
B. Platinum is heavier than mercury.
C. Lead is heavier than iron.
D. Mercury is heavier than lead.

_____

_____

_____

_____

Conclusion: Platinum is_____than sodium.

TABLE I*

SCORE OF EACH GRADE IN EACH SCHOOL ON EACH QUESTION AND TOTAL SCORES

Question No.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*Total*
141 Seniors, Sch. 1	86.7	43.7	57.1	66.9	78.1	17.6	61.9	65.3	44.0	93.8	6.3	82.3	47.3	9.9	79.3	56.0
144 " " 2	80.8	64.2	69.0	72.8	27.6	39.0	50.7	59.1	42.8	93.8	19.4	82.2	70.1	7.0	65.2	58.2
265 " " 3	72.0	46.5	57.4	74.9	28.1	23.5	38.0	48.6	35.5	96.0	19.5	75.2	60.0	9.0	50.1	50.1
550 Total Seniors	79.0	51.0	60.8	71.7	42.5	26.4	48.7	54.5	40.1	94.7	15.6	79.3	59.3	8.9	62.8	54.2
201 Juniors, Sch. 1	87.4	47.2	51.6	66.8	59.4	15.9	42.8	44.8	38.8	73.0	3.0	77.0	62.7	7.5	72.0	51.5
219 " " 2	84.0	59.1	62.2	75.1	27.8	24.7	43.5	49.0	33.3	95.6	11.7	75.8	55.3	10.0	64.2	52.7
230 " " 3	45.9	21.4	70.6	40.0	14.2	7.0	29.2	34.6	15.3	62.7	11.3	47.5	25.5	6.0	26.0	46.1
650 Total Juniors	72.9	43.0	61.8	61.2	34.0	16.0	38.8	43.1	29.3	77.6	8.8	67.3	48.1	7.9	54.4	50.4
277 Soph. Sch. 1	84.9	37.8	49.4	66.0	60.0	9.4	30.0	38.4	35.7	89.5	8.3	67.3	61.4	5.4	74.2	47.9
449 Freshmen, Sch. 1	80.4	30.9	46.9	64.4	63.5	3.8	24.3	35.8	22.8	89.8	6.6	56.9	31.7	3.5	58.8	41.3
240 " " 3	70.3	35.4	49.7	65.2	22.4	2.5	20.0	36.4	29.2	80.6	30.7	53.9	28.5	2.0	40.4	39.7
689 Total Freshmen	77.3	32.3	47.8	64.7	50.8	3.4	21.4	35.9	24.8	87.0	14.0	56.0	30.7	3.0	53.1	40.8
277 8th Grade, Sch.	82.7	30.1	46.2	63.9	50.5	3.6	22.4	24.7	14.4	80.5	8.2	35.5	26.7	1.4	38.7	35.3

* Reference to this table is made on page 127.

DIRECTIONS FOR GIVING AND SCORING THE TEST

Pupils are asked to hand in their papers as soon as completed. When rapid workers begin to hand in the slower ones are stimulated to be more expeditious. Fifty minutes is adequate time for the test.

	Points for Perfect Score
1. To test accuracy of observation. Stars are to be joined, as also leaves. Three points for each pair correctly joined. Subtract two points for each pair wrongly joined.	6
2. To test ability to pick out pertinent elements from a complex situation. (1) 7, 9; (2) 1, 3; (3) 5; (4) None; (5) 4, 6. One point for each of these if correct.	5
3. To test ability to synthesize. O and ow not words; wen and enow are. One point for each word. Owen may not count.	13
4. To test selective recall. Spout on teakettle, pistil in flower, wire from top of receiver to base of instrument. Two points each.	6
5. To test fertility of hypothesis. One-half point for each plausible suggestion.	6
6. Does pupil clearly define a problem before trying to solve it? They can not hit or equivalent answer is correct.	5
7. To test ability to hold in mind a complex of relations. Eight holes in a circle about the center of the square, two in each quarter formed by the diagonals.	8
8. To test problem solving ability—all elements at once. (1) 17, 23; (2) 17, 21; (3) 208, 568; (4) 12/16, 16/24. Two points for each if correct.	8
9. To test judgment on adequacy of data. Conclusion 3 is correct, if it only is marked.	6
10. Does pupil solve a problem scientifically or by the trial and error method. If pencil starts upper route only.	7
11. Does pupil suspend judgment on mooted questions. Two points for each left unmarked.	6
12. Can pupil apply a rule or law? In the first line the 2nd, 4th and 5th. 4's are to be crossed out; second line 3rd; third line 2nd, 4th and 5th. One point for each of these crossed out. Subtract one point for each other crossed out.	7
13. Does pupil test an hypothesis by collecting facts—say, measuring the lines? Lines are equal or equivalent answer.	5
14. Is pupil aware of the danger of reasoning by analogy? If D only is checked.	6
15. Can pupil arrange data in sequence to make the conclusion evident? Correct order B, D, C, A or reverse, 5 points; one more if heavier is filled in	6
	100

The test has now been given to over a thousand students in each of the grades eight to twelve and to college freshmen. The author wishes to express his appreciation to those schools that have so kindly cooperated. The test was given at the mid-year and in the science classes only. There is shown in Table I the percentage of correct answers on each exercise for each of three schools—that are typical of all—together with the average for each question, the average on the whole test for each grade in each school and the total average for each grade level (in so far as the data in hand permit).

It will be noted that the average total scores for the successive grades increase with considerable regularity from the eighth to the twelfth:—35.3, 40.8, 47.9, 50.4 and 54.2%. When these same pupils are grouped by ages rather than by grades this fairly regular increase in the average scores disappears.

The striking thing, however, is the widely different scores made by the pupils of the same grade level on the several exercises of the test and the very different rate of improvement in their skill in the use of the several elements and safeguards as progress is made from the lower grades to the upper. It is evident that some exercises prove many times more difficult than others, and that on some exercises the improvement from eighth grade to twelfth grade is great, on others negligible or even negative. The difference for School 1 between the eighth grade score and the twelfth grade score arranged in the order of magnitude is for each of the fifteen exercises as follows:—exercises number 12, 46.8; 8, 40.6; 15,

40.6; 7, 39.5; 9, 29.6; 5, 27.5; 13, 20.6; 6, 14.0; 2, 13.6; 10, 13.3; 3, 10.8; 14, 8.5; 1, 4.0; 4, 3.0; 11, –1.9. In School No. 3 the difference between the scores of freshmen and seniors give quite a different order to the several questions. Number 7 is still fourth in order as it is above, and 11 fifteenth, the freshmen scoring 11.2% better on it than the seniors. The order on the other questions is so different that there is practically no correlation.

It would appear from these results that ability to think scientifically is a complex of a number of component abilities and that these develop at varying rates and differently in different communities. What the factors are that cause these differences the present study does not reveal. It is interesting to note that the improvement from grade VIII to XII in School No. 1 on the scores of questions 1–5, testing some elements of scientific thinking, is 58.9 while on the exercises (6, 9, 11, 13, 14, 15) testing awareness of the needed safeguards, the improvement is 111.6. The corresponding figures for School No. 3, grades IX and XII are 35.9 and 64.3.

The reliability of the test calculated on the basis of the score on odd and even questions and using the six thousand odd papers now in hand is .993. To attempt a determination of the validity of the test by comparing the grades achieved on it with the teachers' marks in the science subjects seems rather useless for the teachers' grades are based largely on a knowledge of subject matter, not on skill in scientific thinking. Nevertheless this is now being done.

The correlation between the I.Q.'s of the 144 seniors in School No. 2 and their grades on this test is +.66. For the 219 juniors in the same school the corresponding figures is +.47.

Correlating the scores of pupils on the first five exercises, which test skill in the use of several elements of scientific thinking, with the I.Q.'s, the correlation for the 144 seniors of School No. 2 is +.02; for the I.Q.'s and scores on the safeguards—exercises 6, 9, 11, 13, 14, 15—it is +.293; for the scores on elements and safeguards, 0. Similarly for the 219 juniors in the same school the correlation of I.Q. scores and scores on the elements is +.25; of I.Q. scores and scores on the safeguards, +.36; and of scores on elements with score on safeguards, +.055.

The conclusion seems inevitable that general intelligence as expressed by the I.Q. is something quite different from ability to handle either the elements or safeguards of scientific thinking (if these exercises test such ability) and that skill in the use of the elements of scientific thinking is not related to an awareness of the necessary safeguards, at least among these high-school pupils in science classes.

The author has in a previous article[2] presented evidence from this test that seems to show that, in the schools tested, there is no increase in skill in scientific thinking resulting from the science instruction.

The test has been printed merely to facilitate gathering the data needed as a basis for its revision, improvement or replacement. The questions are not in the order of their difficulty, the easy ones first. That order varies in the several grades and even in the same grade in different schools. The present scores for the several questions are tentative; the questions need to be weighted. Validation is needed. It would probably be advisable to replace this test with two, one covering the elements of scientific thinking, the other the safeguards. The former are probably due to inherited abilities, the latter to instruction or experience.

[2] Downing, E. R. Does Science Teach Scientific Thinking? *Science Education* 17: 87–89, April, 1933.

THE STUDY OF BACTERIA IN GRADE FIVE*

GLENN O. BLOUGH

Colorado State College of Education, Greeley, Colorado

During this winter as is often the case during the winter months in elementary schools there were several cases of contagious diseases which are so common among children. Soon after school resumed following the Christmas vacation, two children from the fifth grade were sent home from school because of illness and the cases were diagnosed to be scarlet fever. This situation naturally and properly led to a discussion of the cause of scarlet fever and how it could be communicated. The discussion grew to include consideration of other contagious diseases and when a child suggested that germs were the cause of the disease the children asked several questions about germs or bacteria. We decided to make a study of bacteria and so kept a list of the questions children asked. The list here given contains a few of their questions. They are stated as they were asked by the children.

1. What do bacteria look like?
2. How large are they?
3. Where do they come from?
4. How many times can you have scarlet fever?
5. What kinds of bacteria are there?
6. How do they get from one place to another?
7. Do all bacteria make us sick?
8. What good are bacteria?
9. Are bacteria animals?
10. What do they eat?

Through further discussion and organization, and through additions by the teacher, the following list of important problems was finally organized. It is given here to indicate the scope and nature of the subject matter covered during this study of bacteria. Many of the important problems were finally broken into small questions before they were answered satisfactorily.

1. What are bacteria and what do they look like?
2. How do they grow and what do they need in order to grow?
3. How can we grow bacteria so that we may see them?
4. How were bacteria first discovered and why is this discovery so very important?
5. How are bacteria different from other plants in this room?
6. What are some of the harmful things bacteria do?
7. What are some of the helpful things bacteria do?
8. How do bacteria get from one place to another?
9. What things are done to keep bacteria from spreading in your home? here at school? in stores? in cities? in hospitals?
10. What things can you do yourself to keep bacteria from spreading to and from you?
11. How do scientists find out new things about bacteria?

When this outline was finally organized, the problem arose as to how the questions could be answered. The children suggested these possible methods: (a) Read in science books, (b) experiment with bacteria, and (c) ask people whom we think might know. The teacher suggested growing bacteria in petri shells so that we might use the microscope to see them and so find out how and where they grow and what they look like.

The following activities were then carried out by the pupils:

1. *Reading books to find answers to the questions.* The reading was done as a correlated activity in their classrooms and took places at their regular reading time.
2. *Making bacteria gardens in petri dishes.* The medium in which the bacteria were grown was made by boiling several medium-sized potatoes, filtering the water in which they were boiled, and adding agar-agar. The agar-agar dissolved in the water from the potatoes and was added in order to solidify the carbohydrate material. (When using this kind of a medium it is well to use the fractional sterilization method and sterilize the material on three successive days before it is placed into sterilized petri dishes. This

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insures the killing of spores that are likely to be present in the potatoes.) The petri dishes were sterilized in an electric oven and the culture medium was sterilized by boiling. After the liquid medium was poured into the dishes it cooled and solidified. Each one of the plates was sealed with gum labels to make certain that it would not become contaminated before it was used. (You will find that the bacteria colonies are more easily seen if the culture medium is thin than if it completely fills the petri dish. This entire process of medium preparation was done by a committee of pupils from the fifth grade and the only equipment necessary was that available in any home-economics room. The directions for the preparation of a more effective culture medium may be found in any bacteriology text or laboratory guide. The addition of beef extract and peptone as suggested in these sources insures a greater variety of colonies of bacteria. The potato culture limits the kind to those that feed on carbohydrate foods.)

After the medium had been prepared the following things were selected as interesting possible sources of bacteria. A pupil's hands, dirt from under finger nails, a handkerchief, hair, money, a comb, a fly, and the thumb of a boy who still persists in keeping it in his mouth. The medium was inoculated by breaking the seal and touching the surface of the medium with the article to be used.

From their reading the pupils had found out that a warm dark place was ideal for the growth of bacteria and so such a place was selected. At the end of a few days many colonies of bacteria were found in every bacteria garden. When the pupils were examining the petri dishes one pupil asked this question. How do we know that these bacteria came from a comb? Perhaps they were in the rich material already? Discussion followed and a few new petri shells were filled with sterile food material and this time a control was used. One dish was inoculated with germs from dirty hands, another from the same hands after they had been washed in hot soapy water, and the third, at a child's suggestion, was merely opened and closed at the same time that the two others were inoculated. All three were sealed and kept under the same conditions.

When the results of this experiment were shown to the class they discussed the method of conducting a scientific investigation and here as well as throughout the unit these scientific attitudes were kept in mind: (a) It is not good thinking to jump to conclusions; (b) We must think before we express an opinion; (c) It is better to do your own thinking than to take that of others when you are not sure that they are accurate; (d) Careless experiments are of little value; (e) I will hold my point of view until I am proved wrong; (f) I will try to make sure that my reading material is from an accurate source.

3. *Investigating places in the school building where bacteria may spread* from one person to another and making recommendations about the care of such place as drinking fountains, cafeteria, and boys' and girls' lavatories.
4. *Investigating the school's water supply* and sending a sample to the State Department to make sure that it is safe for drinking. Discussing how water is made safe for drinking.
5. *Conducting an investigation at home to find out where and how bacteria may be spreading.* For example, care of food, towels, wash basins, drinking glasses, tooth brushes, and the care of a sick member of the family.
6. *Making specific suggestions to individuals in class having colds* to make sure that they do not spread them to others in the class, i.e., use of handkerchief, keeping hands clean, not borrowing materials from others, etc.
7. *Listening to a report from one of the class members* who had spent several days in a hospital. (The pupil was taken to the hospital as the result of lodging an article in her throat. She was kept there several days after the removal of the article to make sure that there was no danger of infection. The discussion centered around cautions about putting articles in one's mouth and around precautions taken in hospitals to prevent growth and spread of bacteria.)
8. *Watching the gymnasium instructor care for a floor burn* on a boy's knee. Discussing methods of cleaning it and keeping it away from sources of infection.
9. *Having inspection by a member of the class.* Each day the class met of hands—fingernails, handkerchiefs and habits to make sure that pupils were trying to apply the knowledge.
10. *Learning to transfer a mount of bacteria* from the culture to a slide and to place it under the microscope. Children were not allowed to open the cultures. They were kept sealed. The pupils, however, used prepared slides of bacteria and could also examine the colonies of bacteria with a hand lens through the glass of the petri dish. The teacher opened the bacteria cultures and placed smears under the microscope.

11. *Learning how to operate and care for a compound microscope.* Opportunities were provided for pupils to examine various things under the microscope. A fly's leg was placed under the microscope and the pupils saw the hairs upon which bacteria are carried from one place to another.
12. *Visiting a store* to find things that are done to protect the buyer against food that may contain bacteria. Also to find places that need more careful attention by the storekeeper. A committee from the group visited the store. It did not seem profitable to let the entire class make the visit.
13. *Preparing a report* in the form of written material, talks and drawings to present to other classes in the building to tell them the important discoveries which they should know. (This report included talks by various class members on such topics as : (a) How to keep from catching diseases; (b) How to use the drinking fountains and lavatories; (c) Precautions if you have a cold; (d) What bacteria do for us.)
14. *Preparing an exhibit of the bacteria gardens* and writing an explanation of them telling what they show and what they should teach us.
15. *Preparing a series of talks* to present to a college class in bacteriology to show them what kind of material is included in a bacteria study in grade five.

These culminating activities were carried out with the assistance of the classroom teachers because there was need for clear written expression, good oral presentation and outlining.

The selection of this unit was based upon these criteria for selecting a unit in elementary science:

1. Is the material within the comprehension of this group?
2. Is it interesting?
3. Is it worth while from the standpoint of the effect which it will have on the child's behavior?
4. Is it within the environment and experience of the group?
5. Does it lend itself to promoting individual growth through activities?
6. Does it provide for individual differences in interests and abilities?
7. Will its study be accompanied by progress in the tool subjects?
8. Will its study lead to the development of scientific attitudes on the part of the learners.

The purposes or outcomes of the unit were:

To provide for growth in the use of scientific thinking.
To give knowledge about bacteria, their growth and their effect on other organisms.
To present in graphic form the sources of bacterial infection.
To extend these concepts into the everyday lives of the pupils.

The unit may well lead to the following units for further study:

1. Study of other non-green plants, i.e., molds, yeasts.
2. Study of green plants and their relation to a fifth grade boy or girl.
3. Study of the human body.

Approximately twelve thirty-minute science lessons were used to present this unit. The science classes met twice a week and the reading and other activities took place on the days when the science class did not meet.

The activities other than science have been carried out through the cooperation of Miss Emma Feuerstein and Miss Sadie Tow, of the Lincoln Laboratory School Staff.

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A SURVEY OF GENERALIZED SCIENCE COURSES IN INSTITUTIONS OF HIGHER EDUCATION

MORRIS WINOKUR

College of the City of New York

"The occasion for my thought of such a course was the growing realization of the fact that much college education is fragmentary rather than unified, and that a broad survey of sciences before taking up the special sciences would be quite as useful as a broad historical survey before the intensive study of any particular historical field. In working toward such a course my aim was to give the student a fairly clear conception of what science is and the general scientific method, and sufficient look into the various sciences to guide him in his future study by enabling him to discover his peculiar individual interests."—Pacific College, Newberg, Oregon.

This quotation is typical of a sentiment that is widespread in the United States today. A major criticism of our universities and colleges, often voiced and apparently soundly so, has been that they produce a tremendous number of diplomas but relatively few educated men and women. In contrast, the universities of other countries, like England, have been far more successful in developing greater numbers of really cultured citizens, despite the fact that higher education is there more limited than it is in the United States.

One of the prime factors that has been held accountable for this unsatisfactory situation is that the American student enters upon his field of narrow specialization far too early in his college career. And not alone that, but it is also held that he devotes much too great a portion of his four college years to his specialty, with the consequent exclusion of many varied studies that make for a truly broad and cultured outlook in life.

To remedy this defect in our scheme of higher education, two developments have taken place. In consequence of the growing realization that the first two years of college education are really of the nature of secondary education, there has been created the junior college. The second development has been the movement, fostered by the educational foundations, for greater emphasis on cultural courses in institutions of higher learning.

The aim of these cultural courses, as intended, was to give the student a better understanding of his physical and social environment and an acquaintance with worthwhile leisure activities. The classical curriculum, however, was lacking in such broad viewpoint courses. In the college catalogue the student could find courses like "American History," "Principles of Economics," and "General Sociology"; and he selected certain ones to the exclusion of the others. There was no "Orientation Course in the Social Sciences," a course which would enable him to survey the social sciences and get the viewpoints and major contributions of all of them, and in an integrated fashion. In selecting his special field, the student simply had to make a stab in the dark. There was no course that offered a preview of the various divisions of social science and made possible selection of the specialty on the basis of real exploration. To meet this need the teachers of the separate social sciences collaborated in the formulation of orientation courses in social science.

In the natural sciences the developments have been similar. Mention has been made of the social sciences simply to indicate to the college instructors in chemistry, biology, physics, and the other specialized sciences that this visitation of survey courses has not been limited solely to their field. A glance at the college catalogue will reveal that the studies in the arts also have their

host of appreciation and orientation courses. In his calmer and more objective moments, when he is not giving way to the irritation of the survey course rash, the instructor in chemistry will probably admit that a year's course in biology is not an adequate education in science for the bachelor of arts. Likewise the instructor in geology will very probably insist that for the bachelor of business administration all the major viewpoints of modern science are not represented in the single course in physics. A more or less satisfactory solution of this difficulty has been the formulation of the survey course in science.

The construction of the course, in most instances, has been the cooperative effort of representatives of the different divisions of science, while in a few cases the course has been built by one or two broadly grounded individuals. The relative merits of the two types of formulation can be, and have been, argued at some length, but decision in the matter can be reached only by observation of the comparative success, upon actual application, of the differently constructed courses.

At any rate, the generalized science course is in the college curriculum. And lest anyone, who is completely devoted to his particular branch of science, should hope or imagine that science survey is simply a sporadic or local phenomenon, fated for early discard as an educational fad, he should glance at the writer's list of institutions now offering survey courses in science. This list contains 44 liberal arts colleges and universities, 35 teachers colleges, 11 normal schools, and 14 junior colleges.

This list was arrived at by two methods. The first was an examination of institutional catalogues for the academic year 1934–35. However, in several institutions the generalized science course was still in the tentative and exploratory stage and, therefore, was not listed in the catalogue. Recourse was then had to the publishers of books for use in such courses. They proved very ready in offering adoption lists which subsequent investigation revealed to be somewhat "padded." In the correspondence with the persons conducting science survey courses suggestions of still other institutions were obtained. Consequently, while the list may by this time be incomplete, the procedures utilized were adequate enough to reveal four institutions that were planning to give the course but had not yet formulated it.

After some general correspondence a set of questions was drawn up and sent to 172 institutions. The response to the questionary was encouraging. One hundred forty-four, or 84 per cent, replied. Of these 144, 98, or 68 per cent, were offering a generalized course in science, 42, or 29 per cent, were not giving such a course, and 4, or 3 per cent, were planning to give a course. With regard to the 28 of the 172 that did not reply, it should be noted that the "follow up" letters for the most part brought negative replies. It is therefore probable that most of those who did not answer had no contribution to make to the study.

An examination of the geographical distribution of the colleges offering generalized science is especially revealing. Science survey is certainly not an endemic phenomenon. It is widely distributed throughout the United States and is evident even in the possessions, namely, Hawaii.

The trend in the establishment of generalized science courses in the colleges is indicated by returns to the questionary as follows: 1 in 1919, 1 in 1920, 1 in 1924, 14 in 1927, 5 in 1929, 5 in 1930, 5 in 1931, 4 in 1932, 8 in 1933, 41 in 1934, 11 in 1935 and 4 in 1936. The three dates prior to 1925 were given by teacher-training institutions. It is quite likely that when these institutions were elevated from secondary to collegiate level, their general science courses were transformed into science orientation courses and therefore the dates are probably not valid.

The reasons given by respondees for the establishment of the course are shown below:

Reasons	*Frequency*
Felt need	41
State requirement	22
General education program (Junior college movement)	21
Description at another institution	15
Influence of University of Chicago	7
Influence of University of Minnesota	2
Influence of University of California	1
Jean *et al.* textbook	2
Nature of the World and of Man	2
Outgrowth of a survey course in a single subject area	2
Relieve laboratory load	1
Thirty-first Yearbook of the N. S. S. E.	1

The reasons for the introduction of the generalized science course were accompanied by some interesting and conflicting statements. A few are given.

"There is nothing in administrative practice or philosophy of education to justify courses of this nature."

"We have not become convinced of the wisdom of offering such a course."

"The experience of high schools in general science has not been any too successful, and the various departments do not feel that there is much to be said for orientation in science."

"Survey of science is not a "hash" but a new entity."

"Our objection to a generalized science course is the danger that it will be a course 'about science' rather than 'in science'. We believe it is important to supply an experience background."

"The course should be with laboratory work."

The term "generalized science" course is perhaps not as meaningful as some of the others that have been used, but it is necessitated by the variety of courses that have been established, that is, if names are significant. The titles that are in use and their frequency, as reported in the questionary, are shown in the next column. In general, the emphasis of the courses, as indicated by the titles, would seem to be on the subject matter of science.

Titles	*Frequency*
Science Survey	32
Science	19
General Science	17
Introduction to Science	9
Science Orientation	5
Man and the World	4
Nature of the World	3
Natural History	2
Natural Science	2
Elementary Science	2
Energy and Life	1
Comprehensive Science	1
Development of Modern Science	1

The fields dealt with are revealed by the organization of the courses. In 47 institutions there is offered a single generalized course over the entire area of natural science. Twenty have generalized courses in physical science and a separate generalized course in biological science. Very few have either a generalized physical science or a generalized biological science course alone. A very frequent combination is a generalized course in physical science with some standard course in biology, such as educational, introductory, or human biology. There appears here the appreciation of the fact that the biological sciences—zoology, botany, and physiology—have been available in the integrated form of general biology for some time, whereas the various physical sciences have continued as wholly disparate entities.

Consequently one would suppose that the most evident aim of generalized science courses would be that of integration. Certainly the establishment of a single unitary course dealing with all of natural science would seem to indicate an awareness on the part of the curriculum makers of the fundamental unity of the entire material universe including both the animate and the inanimate. Such is hardly the case, however, if one is to judge from the objectives[1] as expressed in reply to the queries:

[1] The objectives are stated in the language of the respondent. Where there were several variants, the one considered to be the most generally expressive was used.

Objectives	*Frequency*
To give the student a general knowledge of the subject matter of science	54
To acquaint the student with the main generalizations of science	22
To learn to understand the environment	19
To serve as an introduction enabling the selection of regular science courses	14
To understand the scientific method	12
To give the student an appreciation of the scientific attitude	12
To correlate the various fields of science	11
To acquaint the student with the technique of science	10
To show the student the influence of science as an element in civilization	10
To provide the content for the teaching of general science	9
To learn to appreciate the role science plays in modern life	7
To learn to appreciate science and scientific research	7
To acquaint the student with the points of view of science	6
To learn to solve problems in life situations	6
To provide the student with sufficient scientific background for his cultural development	6
To learn to use scientific language with exactness	3
To lay the basis for a balanced philosophy of life	3
To aid the student in better understanding other courses in the curriculum	2
To learn to appreciate the principle of causality	2
To learn that by the organization of knowledge man gains increasing control of environment	2
To fulfill a curricular requirement of a certain amount of science	2
To gain a knowledge of the leading scientists and their contributions	2
To learn to find additional science material	2
To free the student from the unfounded beliefs	2
To reduce the load on laboratory facilities	1
To develop an appreciation of the everyday things of life	1
To become acquainted with the functioning of science in industry	1
To appreciate the constantly changing nature of the environment and of life	1
To supply a knowledge basis for understanding the nature of the child	1
To learn to think better	1
To develop observation and discrimination	1
To develop the ability to read	1
To aid in cultivation of a well-informed Christian personality	1
To learn to appreciate nature	1
To develop an avocational interest in some branch of science	1
To gain an awareness of the possibilities in the socialization of science	1
To become familiar with science	1
To stimulate and discipline the imagination	1
To accent and refine the quality of reverence	1
To give students specializing in one science a general knowledge of the other sciences	1
To open new avenues of interest and satisfaction	1
To lead to broader concepts and wider outlooks	1
To learn to make use of the finding of science	1
To develop social attitudes and appreciations	1

In only 11 cases is correlation of the various sciences a clearly recognized objective. The greatest concern is simply with the transmission of subject-matter or with the main generalizations of science. Orientation as an objective to make possible selection of regular science courses is also somewhat, but not too commonly, recognized. Appreciation of the scientific method and attitude, and of scientific viewpoints and techniques, also receives some attention. In several instances the influence of science in past and present civilization, both as to everyday and industrial affairs, is an aim. The purely appreciational, cultural, and avocational goals are also evident. There are some wholly materialistic objectives like relieving laboratory congestion and providing prospective elementary-school teachers with subject-matter for dissemination. Some rather unusual outcomes are aimed at. In one instance it is found necessary to develop the ability of the students to read (at the college level)! "To accentuate and refine the quality of reverence" is another objective. Is this last compatible with the aims of science itself? The information about the objectives is further elucidated in the re-

sponses concerning the distribution of time for each of the subject-matter areas, as reported later in this article.

In that part of the investigation which dealt with the mechanics of administration of the course there were included queries concerning the total time allotment and its distribution. The returns show the following frequencies of offerings for different intervals of the college course:

Time in School Years	*Frequency*
3 years	1
2 years	13
1 year	47
1½ years	1
½ year	22
⅔ year	12
⅓ year	5

In far the greater number (47) of institutions, the course extends through the full school year. Twenty-two have a one-semester course, while 13 offer a two-year course. In one case each, generalized science is a three-year course and a three-semester course. Several teacher-training institutions devote only two-quarters (24 weeks) to the course or one quarter in which is offered a double course.

The hours per week given to the generalized course vary with the total time available.

Hours Per Week	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
Frequency	0	3	51	19	17	6	1	0	2

Most generally there are three meetings a week. Four and five meetings are also fairly common. A double course brings the weekly hours up to six, and laboratory work raises the total in two cases as high as nine hours.

Perhaps a better realization of variation in the time allotment can be gained from the distribution of the total period-hours in the course:

Period-hours	*Frequency*	*Period-hours*	*Frequency*
30– 39	4	120–129	4
40– 49	0	130–139	5
50– 59	14	140–149	6
60– 69	1	150–174	2
70– 79	1	175–199	12
80– 89	4	200–224	5
90– 99	5	225–249	2
100–109	18	250–299	1
110–119	2	300–360	4

The range in period-hours for the courses reported is tremendous, from a low of 30 hours to a high of 360 hours with no clearly marked mode anywhere. This is certainly an indication that the college generalized science courses are not all cut after one pattern.

How the courses are organized to provide for the different activities is seen by the data assembled below:

Activity organization	*Frequency*
Lecture-discussion combination	54
Lecture plus recitation	15
Lecture only	10
Lecture plus laboratory	7
Discussion only	6
Lecture plus recitation plus laboratory	4
Discussion plus laboratory	1

The favorite organization is a combination of lecture and discussion. However, as many as 15 colleges have separate lectures and recitations, while ten have lectures alone, and six discussion groups only. Twelve institutions include individual laboratory work; four with lectures and recitations also, seven with only lectures added, and one with a discussion period added. The reason for the popularity of the lecture-discussion combination is perhaps expressed by one comment, namely: "We attempt better teaching by carrying the two methods together."

The distribution of lecture hours and recitation hours is revealed by the tabulation of the data, as follows:

Lecture hours per week	*Frequency*	*Recitation hours per week*	*Frequency*
0	7	0	17
1	6	1	12
2	15	2	6
3	49	3	4
4	7	4	3
5	13	5	0
6	1	6	0
		7	1

Where lectures are used, three hours per week is the most common practice. In six institutions each, one and four lectures are given. Two and five lectures a week occur in about the same frequency. One college offering a double course for one-quarter, using only lectures, gives six lectures per week. The fact that a course is listed as a lecture course does not preclude incidental discussion, usually at the beginning and at the close of the period. Of the institutions which volunteered information as to the number of recitations per week, the greatest number used one; progressively fewer employed two, three, and four hours. In one college there are seven hours per week, all devoted to recitation-discussion.

Mention has already been made of the fact that, in general, individual laboratory work is not a feature of generalized science courses, despite the feeling of some that individual laboratory experience in science is necessary for real learning. The returns regarding this item of information show:

Laboratory Hours Per Week	*0*	*1*	*2*	*3*	*4*	*5*	*6*
Frequency	80	3	7	1	2	1	1

To provide for some contact with reality and the materials of science, most schools resort to demonstrations of actual apparatus, specimens, motion pictures, charts, lantern slides, and other visual aids to learning. The data collected show:

No. of Demonstration Periods	*None*	*Few*	*One-half*	*One-third*	*Three-fourths*	*All*
No. of schools	1	16	13	30	7	24

A fair picture of the teaching situation is drawn from typical comments taken from the returns:

The attempt is made to present the fields embraced by the sciences and their applications to and appearances as phenomena in our everyday lives. The class meets in a room equipped with a lantern and a sound projection machine and a completely serviced demonstration table, and unusually frequent use is made of visual material of one sort or another. In all our courses we are making use of every suitable film we can obtain, but most notably in this "Introduction to Science" course. Picture a student sitting in the class with a fossil form in his hand, a picture of the geologic formation in which it was found on the screen before him and the instructor telling how it came to be there. That is the way the course is conducted, so it is only natural that student reaction is pretty favorable, and in consequence, we feel that the course is a success. Of course, it is not perfect and readjustments must constantly be made, but the results thus far are quite gratifying.

In our teaching we make every effort to reify and concretize the subject-matter under discussion. We try to avoid meaningless and empty verbiage that has no connection with the experiences of the students. All of our lectures are illustrated, as are many of the recitations. The difference is that while in lecture a whole series of demonstrations are exhibited and broad areas covered, in recitation one or a few especially significant experiments or specimens serve as a central theme for more thorough discussion. The effort is made in recitation to have the major contribution come from the students.

An especially interesting phase of the recitation work are the discussions of current events in science. These serve to remove the subject from its academic atmosphere and put it into the world of real life. Also, they appear to instil lasting interest in science.

The request for time distribution according to specialized areas of subject-matter, in a few cases, could not be replied to because of thorough integration of the science content. But most respondents were able to approximate the number of hours devoted to the separate sciences. The data are here summarized:

Hours	*Astronomy*	*Geology*	*Physics*	*Chemistry*	*Biology*	*Psychology*
0	2	4	3	2	21	69
1–5	3	3	3	3	0	1
6–10	15	9	6	9	1	16
11–15	40	24	14	18	4	1
16–20	20	28	28	27	5	2
21–25	5	2	9	8	2	2
26–30	3	15	7	13	0	0
31–35	0	1	2	1	0	1
36–40	6	3	7	8	9	0
41–45	..	1	8	0	4	0
46–50	..	0	2	2	12	0
51–55	..	2	2	1	15	1
56–60	..	2	1	1	2	..
61–65	..	..	0	..	1	..
66–70	..	..	0	..	3	..
71–75	..	..	0	..	1	..
76–80	..	..	2	..	1	..
81–85	..	..	..	..	1	..
86–90	..	..	..	..	0	..
91–95	..	..	..	..	1	..
96–100	..	..	..	..	2	..
101–125	..	..	..	..	4	..
126–150	..	..	..	..	1	..
151–165	..	..	..	..	4	..

In astronomy the range is from 0 to 40 hours with the mode at 12. In geology, which includes meteorology and geography, the range is from 0 to 60 with the mode at 18, although 12 and 30 hours are fairly common. In physics the range is from 0 to 80 with the mode again at 18 hours. In chemistry the distribution is much the same as physics. In biology the range is by far the widest, extending from 0 to 162 hours. The scattering is so great that there is no significant mode, although 54 hours is most common. In 21 colleges there is included no biological material at all, while at the other extreme 9 give over 100 hours in biology. As to psychology, in ten institutions it was treated only incidentally as part of the biological area; in 69 schools no attention was given the subject in the generalized course.

The reaction to the question of psychology as a part of the course brought some interesting replies. In one case it was stated that psychology is "not a science yet." Nevertheless some 23 colleges include it in their survey. One devoted as much as 54 hours to it, but ten hours is most common. One institution offers a separate survey course in psychology.

Opportunity was also afforded in the questionary for the listing of any other subject-matter areas outside the specialized areas of science. The replies indicate:

Subject	*Frequency*
Mathematics	6
History of Science	3
Scientific Method	2
Teaching of Science	1
Library Use	1
Photography	1
Labor-saving Devices	1

Mathematics appears most frequently, but the history of science also receives mention. In fact one course uses the historical science as the central theme for the entire course. Some subjects of special attention but of rare frequency are library use, photography, teaching of science and labor-saving devices.

Due to the variation in the total time allotment of courses in different institutions, the per cent of the total time devoted to each of the science subjects is perhaps more significant than the actual number of hours, and is tabulated as follows:

Per cent	*Astronomy*	*Geology*	*Physics*	*Chemistry*	*Biology*	*Psychology*
0	2	4	3	2	21	69
1–10	28	19	10	14	0	17
11–20	41	44	36	46	4	3
21–30	19	21	25	26	18	3
31–40	1	2	15	3	15	1
41–50	1	1	1	0	28	0
over 50	0	1	0	0	6	0

Approximation seems to indicate that astronomy, geology, physics and chemistry receive about equal attention, chemistry perhaps slightly more. Biology, if included in the course, takes up one-third to one-half the time. Relatively little time is devoted to psychology.

Because of the unusual scope of subject-matter and the rapid introduction of the science survey course into the college curriculum, the problems of personnel and administration have proved especially difficult. Who is to teach the course? The attempts at answering this question initially were usually made by the emergency method of utilizing the services of the regular special science instructors, *e.g.*, the physics instructor, the geology instructor, the biology instructor, each contributing his share toward the conduct of the course. The consequence was a course obviously mongrel in application as well as in formulation. Instead of being, as intended, an integrated orientation in science, the course that resulted was simply a mosaic of synoptic summaries of the separate divisions of science. This was shortly realized.

The difficulty in organizing the generalized course is expressed by one respondent as follows:

> "Our two years of experience with such a course was not very satisfactory, due mainly to the unevenness of presentation by various instructors and the practical impossibility of finding an adequately prepared single individual to present the course."

Two-thirds of the colleges, 65 in number, now utilize the plan wherein one instructor remains with the class throughout the course or term. One-third of the colleges (33) change instructors for different areas of subject-matter. A few replies (7) indicate that special lecturers are brought in for particular topics.

The problem of an adequate instructional staff has by no means been completely solved. It can be met satisfactorily in only one way, and that slowly, by the training of special men, broadly grounded in the various sciences, for the teaching of general science on the college level.

However, one cannot disparage the astonishingly excellent professional preparation and training of the men who have been drafted for and are currently functioning in the teaching of science survey courses. Of a total of 288 instructors reported, the academic degrees for 278 are available. Only 17 are limited to the baccalaureate degree. The others, 261 in number, have higher degrees, 100 having the master's degree and 161 the doctorate. It must be noted, though, that the degrees are in many cases extraordinarily particularized. The question arises as to whether this type of training is satisfactory for the teaching of generalized science. Should not greater emphasis be placed upon breadth in professional preparation? Yet it must be admitted that simple listing of degrees does not reveal the probability that many with higher degrees have had graduate or undergraduate training in other than the degree science.

That generalized science has not yet come into its own as a clearly recognized part of the college curriculum is evidenced by the fact that of the 288 instructors (19 institutions not reporting) only 28 devote their entire time to the course and 260 teach other subjects as well, usually the special science courses. This is partly, of course, due to the limited registration in the smaller colleges. However, only five of the colleges have a separate staff for science survey; while in 65 colleges it is the policy to assign the course as a part of the instructor's schedule.

Generalized science, as has been indicated, is increasing in importance and is affecting progressively more of the student population of the United States. In the academic year, 1935–36, the number of students enrolled in the course in 81 colleges is 16,700. There are now some 40,000 students in college who are required to take the generalized course for graduation, and about an equal number who, in most cases, elect the course. Since the returns in these

respects are not complete, the figures are very probably below the actual numbers.

In about one-half of the colleges (46 in number), the generalized science course is a requirement for all of the students. In 15 it is wholly elective and in the others the percentage of students for which it is a requirement varies but shows regular increase from year to year.

The degrees and diplomas for which the course is required vary considerably but most common are teaching certificates, the baccalaureate in the arts, and the junior college diploma or general education certificate. The data show:

Degree	*Number of Colleges*
None	15
2 yr. teach. cert.	31
B.A.	25
B.S. in Educ.	21
B.S.	8
3 yr. teach. cert.	7
(Jr. College Diploma) 2 year general cert.	7
A.A.	5
A.B.A.	1
B.B.A.	1
A.B.Ed.	1
A.G. Jour.	1
B.S. Com.	1
B.S. Law	1

In connection with the mechanics of administration, it is interesting to note the size of classes. About all that can be observed in addition to the tremendous range in numbers in the lecture groups is that the size probably varies simply with the total registration in the course. Most of the recitation classes, however, are kept down to between 25 and 40 students. The tabulated data presented in the next column give a fair picture of the situation as it is revealed by this study.

Number of Students in Lecture Group	*Number of Colleges*
10	2
15	5
20	2
25	9
30	11
35	6
40	6
45	1
50	5
55	3
60	4
65	1
70	1
75	2
80	1
85	2
90	1
95	1
100	4
125	1
150	1
175	2
225	1
360	1

Number of Students in Recitation Group	*Number of Colleges*
15	3
20	2
25	4
30	10
35	5
40	3
45	0
50	2
55	1

In his reply one of the respondents commented significantly about generalized science: "It is a course that is relatively new and rapidly growing and so considerable cooperation is needed in developing it." It is with the hope of lending spur to such cooperation that this study is presented.

AN EXPERIMENTAL COMPARISON OF THE DAILY ASSIGNMENT-DAILY RECITATION AND A UNIT ASSIGNMENT IN HIGH-SCHOOL CHEMISTRY

HARL R. DOUGLASS
Professor of Secondary Education, University of Minnesota
and
GEORGE H. FIELDS
Assistant Principal, West High School, Waterloo, Iowa

This report is intended to describe the procedure and results of a series of three controlled experiments to throw light on the relative efficiency of a daily assignment and a large unit assignment plan of teaching.

THE EXPERIMENTAL VARIABLES

In the large unit method the course in chemistry was divided into the following related units:

I. The Nature and Composition of Matter and the Nature of Chemical Change
II. A Common Compound, Water, and its Constituent Elements
III. Some Chemical Theories
IV. Symbols, Formulas, and Equations
V. Some Typical Compounds, Acids, Bases, and Salts
VI. Solutions and Colloids
VII. The Air and its Components
VIII. Some Non-metals (The Halogens, Sulfur, the Nitrogen group)
IX. Carbon and Fuels
X. Organic Carbon Compounds
XI. Iron and Steel
XII. The Non-ferrous Metals
XIII. Chemical Calculations
XIV. Radio-activity

They were of sufficient length to require from two to four weeks each for completion. A typical unit included (1) a general outline of the work embraced by the unit, (2) a list of readings on the topic (these were taken mostly from chemistry texts although other science books and magazine articles were also used, (3) a list of special topics of general interest; such as, photography or matches, together with references, and (4) a list of optional experiments. All assignments were mimeographed.

At the beginning of the study of a unit a day (or more if necessary) was taken up with a general discussion of the unit and the problems involved provoking discussions of the things included in the unit. Pupils were then put on their own responsibility for finding and assimilating the assigned material. Reference books were available in the classroom and the entire class period for several days, varying with the length of the unit and its difficulty, was given over to study. During this time the pupils were urged to bring to the instructor for solution or discussion any problems that they had found too difficult for them alone. After sufficient time had elapsed for all students to read the references and to do the assigned laboratory work a class period or more was devoted to another general discussion of the unit and its special topics. Special difficulties were noted and smoothed out. Following this a test was given over the unit. The results of this test were used as a basis for further study and discussion.

THE "DAILY" METHOD

In the sections using the Daily Assignment-Daily Recitation method subject matter was assigned in such units that one could be covered in a single recitation period. Every effort was made to make the breaks in the chapters at logical points so that no disadvantage would arise from an illogical division. Written assignments were made for this group so that no difference would result from a more definite assignment in the other group. Since the double period plan of supervised study is used in this school, both groups had the same oppor-

tunity to consult with the instructor about their individual difficulties during the study periods. The daily recitations brought out the group discussion and the group problems. Topics suggested as collateral reading for the Unit Assignment group were here given as special reports. The usual recitation consisted of discussion by the pupils of the material in the assignment, oral reports by pupils on special topics, and supplementary discussion by the instructor of important points not brought out by the pupils.

Both groups had the same subject matter presented in approximately the same sequence. The total amount of time spent on any large division of subject matter was the same. Every effort was made to narrow the variable factors down to (1) the length of the assignment and (2) the responsibility placed on the pupil to get and organize his own material so that he might see not isolated facts but a unified whole.

EQUATING OTHER VARIABLES

Certain sections of chemistry in the West Waterloo (Iowa) High School were taught with the "daily" method and others with the "Large-Unit" Method—all by the same instructor, Mr. Fields, co-author of this report. With all sections the same textbook was used, the same number of class meetings of 60 minutes each were employed, pupils in the three sections were paired as to sex, age, grade, and ability, and it was believed that all but the experimental variables were held reasonably constant. The various sets of classes were equated on the fourfold basis of sex, school classification, chronological age, and I.Q. calculated from scores on the Terman Group Test of Mental Ability. Paired individuals were of the same sex and school classification. Due to scheduling difficulties, it was not possible to shift pupils in order to balance the sections either in size or any other factor. This, together with the method of equating the experimental groups, necessitated dropping from the experiment those students who were at the extremes in I.Q. and age as well as several who were of odd classification or repeaters. All pupils considered in the experiment were either juniors or seniors.

Data throwing light on the equivalence of the various pairs of sections are given as Table I. Pupils in Unit I had had no previous training in chemistry; those in Units II and III had had one semester.

TABLE I

DATA RELATIVE TO EQUIVALENCE OF VARIOUS PAIRED GROUPS

Group	*No. Cases*	*Mean Age*	*Mean I.Q.*	*Mean Initial Score, Powers Test*[1]
Unit I				
D A–D R	29	16 yr. 2.1 mo.	104.3	2.93
Unit Assignment	29	16 yr. 2.7 mo.	103.5	3.00
Group	*No. Cases*	*Mean Age*	*Mean I.Q.*	*Mean Initial Score, Powers Test*[1]
Unit II				
Group A	26	16 yr. 4.0 mo.	102.1	21.19
Group B	26	16 yr. 3.7 mo.	102.3	24.07
Group	*No. Cases*	*Mean Age*	*Mean I.Q.*	*Mean Initial Score, Powers Test*[1]
Unit III				
D A–D R	18	16 yr. 6.4 mo.	104.5	17.7
Unit A	18	16 yr. 7.1 mo.	104.2	18.7

[1] Initial scores for Unit II were the same as final scores for Unit I. Different pupils were used in Unit III; there is no relationship between these scores and those of the other unit.

MEASURING PROGRESS

In measuring the achievement of the experimental groups Powers General Chemistry Test, Form B, was used. This test is made up of two parts: Part I is a test of range of information about chemistry and is composed of thirty items including chemical history, chemical properties, chemical composition, commercial processes, and terminology: Part II consists of thirty-seven items and tests ability to give chemical names of common substances, write formulas, and equations, and make simple calculations. The time allowed for this test is thirty-five minutes. All questions in Part I are of the multiple choice type and all of those in Part II are completion. The reliability of the test as listed by the author is .80 ± .02.

TABLE II

COMPARISON OF ACHIEVEMENT OF MATCHED PAIRS, UNIT I

	Unit Assignment Group	*Daily Recitation Group*
Mean I.Q.	103.5	104.3
S.D.	8.61	7.53
Mean Initial Score	3.00	2.93
S.D.	5.76	7.59
Mean Final Score	21.69	24.69
S.D.	4.80	5.46
Mean Gain	18.69	21.75
S.D.	5.46	4.83
Mean Per Cent Gain	29.1	33.7
Mean Gain Group with I.Q. > Mean	20.4	25.2
Mean Per Cent Gain Group with I.Q. > Mean	32.1	38.8
Mean Gain Group with I.Q. < Mean	16.9	18.3
Mean Per Cent Gain Group with I.Q. < Mean	26.2	28.0
Mean Per Cent Gain Entire Group (UA plus DR)	31.6	

In the third unit of the experiment a test constructed by Mr. Fields was given both at the beginning and at the end of the experimental period. The test consisted of 100 items. Sixty-one of these might be classed as informational, of which twenty-one were multiple choice, eighteen completion, and twenty-two matching. The remaining thirty-nine items tested ability to perform certain tasks: such as, writing equations, writing formulas, and solving problems. This test had been used by the author previously and its reliability determined. The reliability of one half the test was found to be .85 ± .008 by the method of odds and evens which when stepped up to give the reliability of the whole test by the Spearman-Brown formula became approximately .92 ± .01. Gains and scores were computed in the same way as for the Powers test.

TABLE III

COMPARISON OF ACHIEVEMENT OF MATCHED PAIRS, UNIT II

	First Nine Weeks		*Second Nine Weeks*	
	UA	*DA–DR*	*UA*	*DA–DR*
Mean I.Q.	102.1	102.3	102.3	102.1
S.D.	8.32	8.16	8.16	8.32
Mean Initial Score	21.19	24.07	30.53	28.51
S.D.	4.86	6.09	6.96	7.53
Mean Final Score	28.51	30.53	33.69	31.30
S.D.	7.53	6.96	8.79	6.60
Average Gain	7.31	6.46	3.16	2.79
S.D.	5.38	6.05	4.40	3.79
Average % Gain	16.10	15.06	10.30	6.36
Mean % Gain Entire Group	15.58		8.34	

RELATIVE PROGRESS OF EXPERIMENTAL AND CONTROL GROUPS

Relative progress could be measured in terms of gain, or in terms of final status or in terms of per cent of possible gain. Data of all three types are given in Tables II, III, IV, and V.

TABLE IV

COMPARISON OF ACHIEVEMENT OF MATCHED PAIRS, UNIT III

	Powers Test	
	Unit Assignment	*Daily Recitation*
Mean I.Q.	104.2	104.5
S.D.	3.21	3.15
Mean Initial Score	18.7	17.7
S.D.	5.45	4.12
Mean Final Score	27.5	28.4
S.D.	7.44	8.76
Mean Gain	8.79	10.7
S.D.	5.62	5.97
Mean Per Cent Gain	18.1	22.6
Average Gain Group with I.Q. > Mean	10.1	12.2
Average Per Cent Gain Group with I.Q. > Mean	22.3	26.6
Average Gain Group with I.Q. < Mean	7.4	8.1
Average Per Cent Gain Group with I.Q. < Mean	14.2	17.1
Mean Per Cent Gain Entire Group	20.3	

RELIABILITY OF THE INDICATED DIFFERENCES IN GAINS

An examination of the preceding tables reveals considerable difference in results. If the matched groups only are considered we find that in three of five cases the group using the daily assignment and recitation exceeded the unit assignment group in actual achievement as based on final scores. On the other two occasions the unit assignment group made superior showings. When gains are considered the reverse is shown, the unit assignment group making the greater gains on three occasions and the daily assignment on two.

The question naturally arises as to whether these differences are due to a real difference in the experimental factors or to chance errors of measurement or sampling, or to some systematic error. Every effort was made to avoid systematic errors by limiting the difference in methods of instruction to the experimental variable and holding constant such factors as, number of class periods missed, absences, etc. Since we can assume that the distribution of chance errors is "normal," the extent to which the differences are beyond the realms of chance can be calculated. By using the formula

$$SD_d = \sqrt{SD^2_{m_1} + SD^2_{m_2} - 2r_{m_1 m_2}\, SD_{m_1}\, SD_{m_2}}$$

and assuming $r_{m_1 m_2}$ to be approximately equivalent to $r_{g_1 g_2}$, the correlation between the gains, we can determine the SD_d for the matched groups in each experiment. Then by the ratio d/SD_d we can estimate the chance that the real difference is greater than 0, and that the group judged superior. The chance per thousand that the differences are real, barring systematic errors, are shown in Table VI.

TABLE V

COMPARISON OF ACHIEVEMENT OF MATCHED PAIRS, UNIT III. AUTHOR'S TEST

	Unit Assignment	*Daily Recitation*
Mean Initial Score	31.29	33.47
S.D.	8.61	11.22
Mean Final Score	41.69	40.87
S.D.	9.78	13.9
Mean Gain	10.4	7.4
S.D	5.55	5.25
Mean Per Cent Gain	14.9	11.9
Average Gain Group with I.Q > Mean	9.7	9.8
Average Per Cent Gain Group with I.Q. > Mean	15.6	16.3
Average Gain Group with I.Q. < Mean	11.7	5.2
Average Per Cent Gain Group with I.Q. < Mean	14.5	7.9
Mean Per Cent Gain for Entire Group	13.4	

TABLE VI

DATA RELATIVE TO RELIABILITY OF DIFFERENCE BETWEEN EXPERIMENTAL AND CONTROL GROUPS

	d	SD_d	$\frac{d}{SD_d}$		Chances/1000
Unit I					
Final Score	3.0	1.02	2.94	DR > UA	998
Gain	3.06	1.17	2.61	DR > UA	995
Unit II				*First Nine Weeks*	
Final Score	2.02	1.96	1.03	DR > UA	849
Gain	.86	1.2	.716	DR > UA	763
				Second Nine Weeks	
Final Score	2.39	2.30	1.03	UA > DR	849
Gain	.37	1.12	.330	UA > DR	629
Unit III					
Powers' Test					
Final Score	.9	2.1	.428	DR > UA	666
Gain	1.91	1.6	1.193	DR > UA	884
Author's Test					
Final Score	.82	3.21	.025	UA > DR	510
Gain	3.0	1.62	1.85	UA > DR	968

SUMMARY OF CONCLUSIONS

In summarizing conclusions indicated by results of the study, the author would say that:

1. Neither method seems to be distinctly superior or to produce consistently better achievement in high school chemistry classes regardless of the personnel of the group;

2. The evidence seems to indicate a greater probability that the Unit Assignment may result in slightly better achievement than the Daily Assignment and Recitation;

3. Factors other than method are responsible for most of the superiority shown in achievement by one of a pair of individual pupils;

4. The evidence is not at all conclusive that achievement by either method shows a higher correlation with I.Q. but data favor the Unit Assignment;

5. The Unit Assignment is at least equal to the Daily Assignment and Recitation as a means of imparting information about chemistry, and, if it has other unmeasurable benefits not possessed by the Daily Recitation, is worthy of a trial.

AN EXPERIMENT IN THE TEACHING OF THE PRINCIPLE OF PHOTOSYNTHESIS

MARION V. MAGRUDER
Biology Instructor, Western High School, Washington, D. C.

The District of Columbia Course of Study in Biology was prepared by a committee of four high-school biology teachers, working under the direction of the head of the Department of Science, over a period of about thirty months. The first six months were spent largely in study; the next twelve were required for developing a tentative course; the last year was set aside for application in the classroom and for revision. The questions of sequence and placement of materials, thought necessary for attaining the aims of the course of study, kept presenting themselves throughout. During the trial period, one of the most frequent criticisms was in regard to the excessive material in relation to the amount of time.

Out of these difficulties arose the following problems in connection with the unit on food-making: (a) How would the understanding of the principle of photsoynthesis be affected if the structural detail now included in the unit were reduced to a minimum? and (b) How would the understanding of the principle of photosynthesis be affected if the structural detail now included in the unit were presented in a previous unit dealing with the relationship of organisms to environment, and not in the one on photosynthesis?

As an approach to the solving of these problems concerning amount and placement of certain subject matter, a three-day plan for teaching the unit on photosynthesis was prepared. The first or *A* plan presented the principle according to the District course of study, but with only such structural detail as Downing[1] included in a similar unit. The second or *B* plan, which served as a control, presented photosynthesis according to the course of study. The third or *C* plan presented it according to the *A* plan, but followed a unit on adaptation to environment in which the same structural detail appeared that was presented in plan *B*. In all three plans, photosynthesis was given the major emphasis within its own unit. The same teacher prepared all three plans. The problematic approach was employed throughout the teaching experiment, much time being given to the solving of related problems which are associated with life experiences. The plans were presented by the same teacher to three separate groups of pupils equated according to age, I.Q., and previous semester's biology rating. The time schedule was so planned that all three groups were tested on the same days, each having been allowed the same amount of time for the actual study of photosynthesis.

Prior to launching the experiment, the pupils and their groupings were analyzed. Their ages, in months, ranged from 170–240; their I.Q.'s from 76–134; their previous semester's biology ratings from below average or D to superior or A; their grade placements from 10a–12b. There were thirty-six boys and ninety-four girls. This group was divided into four classes, primarily for convenience in arranging programs. There were twenty girls and eleven boys in the first class, mostly in the eleventh and twelfth grades. Their ages varied from 178–240 months; their I.Q.'s from 84–127. There were twenty-eight girls and eight boys, mostly in the tenth grades, in the second class. Their ages varied from 171–233 months; their I.Q.'s from 86–133. There were twenty-eight girls and four boys in the third class, also for the most part in the tenth grades. Their ages varied from 170–204 months; their I.Q.'s from 92–127. The fourth class consisted of seventeen girls

[1] Downing, Elliot R. "An Investigation," *North Central Association Quarterly*. March, 1931. pp. 453–470.

and twelve boys, mostly tenth-grade students. Their ages ranged from 170–206 months; their I.Q.'s from 76–134.

Out of these classes there were seventeen pupils who could not be used in the experiment for various reasons. The experiment, then, was tried on 118 pupils, of whom only 90 could be equated.

Since the second, third and fourth classes were most nearly alike in grade placement, being composed largely of tenth-grade pupils, it seemed logical to select them as the three experimental groups. Consequently the second was designated as Experimental Group *A;* the third as Control Group *B;* the fourth as Experimental Group *C*. The control group, however, showed less variation in age, I.Q. and ratings than did the other two groups and therefore had less material for equating and probably a better chance of success. Also the number of boys was fewer than in either of the other two groups. Because of these factors, the first class was designated as Control Group *B* also and coupled with the third class in all final results.

The actual equating was based upon age, I.Q. and previous semester's biology rating. A pupil in one group paired with one in another group when the age difference did not exceed ten months, the I.Q. not more than five points and the previous semester's ratings were similar. From group *A*, twenty-six pupils equated with pupils in the combined group *B*, and nineteen with group *C*. Twenty-three group *C* pupils equated with pupils in group *B*. Table I gives an example of how the groups were equated.

TABLE I
AN EXAMPLE OF EQUATING

Group A			*Group B*		
Age	*I.Q.*	*Rating*	*Age*	*I.Q.*	*Rating*
176	130	A	170	127	A
179	115	B–	[illegible]	114	C+

In the *Course of Study in Biology for the Senior High Schools of the District of Columbia,* Unit VII has for its title *Food-making Processes in Plants.*[2] The following subsidiary generalizations were chosen as objectives for the unit:

A. Food getting is one of the chief problems of animals.
B. Green plants make their own food.
   1. Sunlight is the source of energy in food-making.
   2. Photosynthesis takes place only in the presence of chlorophyll.
   3. Carbon dioxide and water are the raw materials used in photosynthesis.
   4. Protein synthesis and fat making take place in green plants.
C. The somatic organs of plants are concerned primarily with food-making.
   1. Roots absorb water, nitrates, phosphates, etc., by osmosis.
   2. Stems are essentially for transportation and for the support of leaves to sunlight.
   3. Leaves are the chief organs for food-making.
D. Plants which lack chlorophyll are dependent upon other organisms for food, either directly, as parasites, or indirectly, as saprophytes.

The committee hoped that mastery of these ideas would lead to an understanding of the principle, "the ultimate source of the energy of all living things is sunlight," through problems and situations directly concerned with life experiences.

It was with the understanding of this principle as the ultimate aim of the unit that the three-way plan of procedure, used in this experiment, was devised.

Photosynthesis was taught Control Group *B* according to the District of Columbia course of study. The presentation was briefly:

1. If you were to find yourself shipwrecked on an uninhabited island, how would you go about meeting the food-getting problem?
2. How would the animals and the plants that you might find in your search be solving the same problem?

[2] Board of Education, District of Columbia, *Course of Study in Biology for the Senior High Schools.* pp. 19–21.

3. Why do all living things need food?
4. What is food?
5. Since plants are said to be the source of all food, how do they make it?
6. How do the plants secure the materials from which to make food?
7. By what process does water enter the roots of plants?
8. How do roots increase their absorbing surface?
*9. How is the root tip adapted to go after fresh supplies of water?
*10. What structural adaptations enable a root to pass substances inward and upward?
*11. For what, besides absorption, are roots important?
*12. What are some of the different types of roots and for what is each specialized?
13. What substances, other than water, are generally absorbed through the roots?
14. How do these substances get into the soil?
15. If food-making takes place mostly in the leaves, how do substances absorbed by the roots reach the leaves?
16. How can one show that liquids rise in stems through fibrovascular bundles and enter the leaves through their veins?
*17. For what do plants need stems other than for transportation and support of leaves to the light?
*18. What structural adaptations enable a stem to carry out its various functions?
*19. What are the external characteristics of a woody stem and what are their significance?
*20. How does a monocot stem differ from a dicot stem in regards to transportation, support and storage?
*21. How does a woody stem increase in circumference and what has this to do with transportation?
*22. What is the significance of the arrangement of veins in a leaf and what are some of the characteristic patterns?
23. How does the plant secure the carbon dioxide necessary for food-making?
24. What besides carbon dioxide and water are known to be necessary for starch making?
25. How is a leaf adapted to expose chlorophyll to sunlight?
26. How does photosynthesis differ from respiration?
27. What food substances, other than starch, are found in green plants?
28. How do plants that lack chlorophyll secure their food?
29. Defend the statement, "the sun is the source of life energy."

The time allowed for this presentation was twenty-nine forty-five minute periods or about five six-period weeks. This time includes the presentation, review, drill in problem solving and the two-period test at the end.

Photosynthesis was taught to Experimental Group *A* according to the course of study except that only the amount of structure included by Downing in his unit was presented. If the starred articles are omitted from the presentation to Control Group *B*, the set-up for *A* is obtained.

The time allowed for this presentation was twenty-four forty-five minute periods or about four six-period weeks.

Photosynthesis was taught Experimental Group *C* just as it was to *A* but following a unit in which structure was presented, briefly:

1. For what are aquatic plants dependent upon the water in which they live?
2. What are some of the changes that plants have had to make to adapt themselves to terrestrial conditions?
3. What devices have plants developed for securing water from the soil?
4. What other value have roots to plants besides absorption?
5. What are some of the types of roots that have developed and why?
6. Why do some land forms develop tall woody stems or climbing devices?
7. How are stems adapted to carry on transportation?
8. What are some of the structural differences found in stems and why?
9. How do liquids brought up from the roots finally reach the leaves?
10. What is the significance of the various vein patterns?
11. How are plants adapted for water conservation in dry regions?

The time allowed for this preliminary unit and for the actual study of photosynthesis was thirty-one forty-five minute periods or about five six-period weeks.

With all three presentations experiments, charts, models, pocket gardens, moving pictures, etc., were used for demonstration purposes.

At the end of the presentation and review period, a sixty-five point objective test was given each class. Two thirty-five minute periods were allowed for the test which was divided into two halves. The test was constructed by the experimenting

teacher after a careful analysis of a number of published tests. The test aimed to determine to what extent the pupils had acquired a knowledge and understanding of photosynthesis as the means by which life energy is derived from the sun. Six biology teachers, other than the experimenter, passed on the validity of the test.

At the end of two weeks, during which time the corrected first test had been gone over with the pupils, drill in a five-point summary of photosynthesis was given and the next unit started, a short retest was held.

The following results and conclusions are based upon the scores for these two tests. The scores obtained from the first test for all 118 pupils formed a fairly regular normal curve of distribution, beginning at 25.5 and ending at 64 points out of the possible 65. The median was 46 and the mean 45.6 points. A comparison of means for the four classes and for the three groups are shown in Table II.

TABLE II
A Comparison of Data Obtained from the First Test for the Four Classes and for the Three Groups

Class	*No. of Pupils*	*Mean Scores*	*Median Scores*	*I.Q. Means*
First	30	43.8	44.0	109.2
Second	34	45.2	47.0	113.7
Third	28	47.8	47.5	111.0
Fourth	26	45.9	45.3	110.6
Group B	58	45.7	45.7	110.1
Group A	34	45.2	47.0	113.7
Group C	26	45.9	45.3	110.6
Totals	118	45.6	46.0	111.1

Although group *A* has the highest I.Q. by 2.7 over the nearest group, it falls 2.6 below that same class in score mean for the first test. Of the control classes, one has the highest and the other the lowest test mean.

By combining the control classes, the three groups compare: *A*–45.2, *B*–45.7 and *C*–45.9. The differences are obviously too slight to have any significance.

Table III shows the results obtained from the first test for the equated groups.

TABLE III
Comparison of Data Obtained from the First Test for the Equated Groups

Groups	*No. of Pupils*	*Mean Scores*	*Median Scores*	*I.Q. Means*
Experimental A ..	26	44.0	43.2	112.5
Control B ..	26	46.1	45.5	112.4
Control B ..	23	44.9	45.5	111.5
Experimental C ..	23	45.6	47.5	111.0
Experimental A ..	19	44.1	43.5	112.8
Experimental C ..	19	47.3	50.0	112.4

Group *C* shows .7 points higher mean than does group *B* and 3.3 points higher mean than does group *A*. Group *B* shows a 2.1 gain over group *A*. In each case, the group that had had structure showed a few points gain over the group that had had less structure.

The brief retest that was given two weeks later was scored fifteen points, if perfect; one point for each of ten true false statements, to be corrected if false, and five for a five point summary of photosynthesis, upon which drill had been given the previous week. Table IV shows the results obtained from the equated groups.

TABLE IV
Comparison of Data from the Retest for the Equated Groups

Groups	*No. of Pupils*	*Mean Score*
Experimental A	24	11.8
Control B	24	12.6
Control B	22	12.5
Experimental C	22	12.0
Experimental A	19	11.6
Experimental C	19	12.0

Control Group *B* shows a gain of .8 over *A* and a gain of .5 over *C*. Experimental Group *C* shows a gain of .4 over *A*. Again those groups that had had structure, showed a slight gain over those that had had less

structure. Unlike the first results, *B* is slightly ahead of *C*.

When, however, the formula,

$$P.E._{.m^1-m^2} = \sqrt{(P.E._{.m^1})^2 + (P.E._{.m^2})^2}$$

was applied to determine the probable error of differences between two means, and the differences between the two means was divided by the results, the quotients fell below the amount needed to indicate a significant difference.[3]

Table V shows the results of these various calculations for the first test.

TABLE V

Comparison of Data from the First Test for the Equated Groups with Corrections for the Probable Error of Differences and Calculations for the Critical Ratio

Group	*Mean*	*Standard Deviation*	*Probable Error*	*Mean Difference*	*Prob. Error of Dif. Bet. Two Means*	$\frac{D}{P.E.\ of\ Diff.}$
A	M_2	S_2	P.E.M_2			
26	44	9.45	1.25	2.1	1.8	1.16
B	M_1	S_1	P.E.M_1			
26	46.1	9.49	1.25			
B	M_2	S_2	P.E.M_2			
23	44.9	9.13	1.28	.7	1.8	.38
C	M_1	S_1	P.E.M_1			
23	45.6	8.87	1.25			
A	M_2	S_2	P.E.M_2			
19	44.1	10.2	1.58	3.2	2.1	1.52
C	M_1	S_1	P.E.M_1			
19	47.3	9.24	1.42			

Similar calculations for the retest showed a similar lack of significance.

SUMMARY AND CONCLUSION

Questions pertaining to the amount and placement of structural detail necessary for understanding certain biological principles arose in connection with preparing a course of study in biology for the senior high schools of the District of Columbia. In order to settle some of these questions, a three-way experiment on the teaching of photosynthesis was performed. To one group of pupils, photosynthesis was taught with the traditional structural detail reduced to a minimum. To another group, equated with the first, it was taught with the traditional amount of structural detail retained. To the third group, equated with the other two, the structure was taught prior to photosynthesis to show adaptation to environment. The groups are then given two tests with a two-week interval between them. Although the results showed that the structure groups were several points ahead of the non-structure group, when corrections were made for probable errors of the means and of the difference between two means, the differences were too small to have any significance.

From this, one might conclude that the amount and placement of structural detail has little or no effect upon the understanding of the principle of photosynthesis. If this is true, the five or six additional periods needed for teaching the structure might better be spent upon some other subject-matter in a crowded curriculum; unless some value other than the understanding of photosynthesis has sufficient weight to justify the time spent.

[3] Holzinger, Karl. *Statistical Methods for Students in Education.* New York: Ginn & Company, 1928. pp. 102, 235–237.

CURRICULUM ANALYSIS AS A BASIS FOR DETERMINING SCIENCE ROOMS, SERVICE, AND FURNISHINGS IN TEACHERS COLLEGES*

HARRY A. CUNNINGHAM
Kent State College, Kent, Ohio

Laboratory work carried on in rooms somewhat specialized for the purpose has been one of the most important characteristics of science teaching. The specialized material facilities that are deemed necessary for science teaching are expensive. It is important, therefore, that science people should not only furnish all possible evidence to show that laboratory work is necessary in the teaching of science but also to show that they have selected the material facilities to use in science instruction that are really necessary and most important. Science teachers must show that laboratory activities are supposed to assist in the attainment of valid objectives of science teaching and then, as rapidly as possible, produce evidence to demonstrate that the laboratory activities are actually making such contributions.

It has been assumed in this study that, in the training of science teachers, one is not only concerned with the job of selecting the laboratory activities necessary as a part of one's general education but also in giving the college student, preparing to teach, the training in the performance of the laboratory activities that are deemed necessary as a part of the experience of the pupils in the grade, or grades, in which he is going to teach. In the professional training courses the latter purpose mentioned above is, of course, the dominant one. This training of science teachers should be just as much a specialized preparation as the preparation for law, medicine, dentistry, or engineering.

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Hurd,[1] in reporting a recent study, came to the conclusion that "a professional course should seek to train teachers to perform the kind of teaching tasks which they will be expected to do later. Conventional subject-matter courses designed for no particular group are poor devices for training teachers." Thus we see that the teacher in training for the teaching of science needs to learn to perform those laboratory activities that the pupils whom he is to teach will need either to perform, or to see performed, as a part of their general education. Those laboratory activities that the teacher will, in his teaching, either need to direct the performance of, or perform himself as demonstrations, should certainly be included as individual laboratory work in his professional training. The college student as part of his professional training for the teaching of science must also perform, or see performed, whatever laboratory activities are deemed necessary to give him the understandings which are needed beyond the understandings that he will be called upon to use directly in teaching. These latter laboratory experiences may probably be given him effectively by lecture demonstration.

The objectives for the teaching of science, particularly grade science, have undergone radical changes during the last few years. It is very evident that science rooms used in the accomplishment of the former objectives of elementary science will not be so suitable for the accomplishment of present objectives. This fact is well exemplified at present by a study of the rooms that are

[1] Hurd, A. W. "An Analysis of Some Professional Subject-Matter Courses in Science in Teacher-Training Institutions." *Science Education* 17: 277–280; December, 1933.

now being used in some of our best teachers colleges to train grade teachers in science. The writer, in a recent unpublished study of The Material Facilities Used in the Training of Intermediate-Grade Teachers in Science[2] in seventeen outstanding teachers colleges of the country found that:

1. There is little or no uniformity in the names of courses given in science for the training of intermediate-grade teachers in the schools studied.
2. Many teachers colleges provide little or no facilities for training intermediate-grade teachers in physical science.
3. Aside from the rooms that are used for classroom work, either recitation or laboratory, there is not much uniformity as to rooms such as growing rooms, animal rooms or animal houses, preparation rooms, museums, etcetera, which are used in the training of intermediate-grade teachers.
4. There is not much uniformity in the type of room used for class work or laboratory work.
5. These rooms, in which class work and laboratory work are carried on, may be classified into five types: (a) recitation; (b) recitation plus laboratory; (c) recitation or laboratory; (d) laboratory; (e) lecture demonstration.
6. None provide, in a satisfactory manner, for independent supplementary project work which is now being emphasized and in which many of the teachers of these teachers' courses are interested.

The gist of the material in the Thirty-first Yearbook, Part I, of the National Society for the Study of Education on this topic is that laboratory activities must proceed from the science curriculum.[2] The following quotations from this publication will make this point clear:

1. A science room is a place where the pupil may receive educative experiences which add meaning to, and give better understandings of, those generalizations in science that contribute to enrichment of life.
2. Science room experiences are justified by, and take their origin from, the science curriculum, course of study, and learning experiences to be expected of pupils.
3. A piece of equipment or apparatus is to be evaluated in terms of the educative experience which it makes possible.

In other words, the laboratory activities of boys and girls should be dictated by the science curriculum and it is the job of the professional courses for teachers to give training in the activities that are found fundamental in the science curriculum for the particular grade, or grades, under consideration.

It is assumed in this study that science education, as well as all education, is aimed primarily at the training of individuals so that they will react as intelligently as their organisms will permit to life situations. In order to act intelligently to a problematic life situation one must be able to experience vicariously, by language, most of the possible reactions to the situation—experience quickly and vicariously the success or the failure of each language try-out and then try overtly the activity or reaction that has been most successful in the language try-out. One is said to react intelligently when the correlation between success in the language try-out and in the overt trial is positive and high. Now what kind of language equipment is most desirable in the field of science?

In the first place, one needs to experience by language activity the relationship between certain natural phenomena called causes which precede others called effects. To this type of activity we have attached the term generalization. Before we can experience these relationships vicariously, by language, we must have either the exact experience overtly, or an experience very similar to the exact one, or experience at different times the elements of the more complex exact experience so that the elements of the exact experience may be organized vicariously and a total vicarious activity very similar, at least, to the real one synthesized. The job seems to be to attach language symbols to as many of the fundamental interactions in nature as possible so that the real interactions may be represented, in their absence, by language symbols.

The data for this study have been obtained by: (1) the analysis of 14 courses of study in science for grades 4, 5, and 6 all

[2] National Society for the Study of Education. *Thirty-first Yearbook, Part I. A Program for Teaching Science.* Bloomington, Illinois: Public School Publishing Company. p. 291–295.

of which are ranked in the upper quartile by the Bureau of Curriculum Research, Teachers College, Columbia University; (2) an analysis of nine books and laboratory manuals written for teachers of elementary science; (3) an analysis of twenty-five books written specifically for pupils studying science in the fourth, fifth, and sixth grades; and (4) an analysis of thirty-nine books and laboratory manuals not written specifically for use in the intermediate grades by either pupils or teachers but which were either referred to in the courses of study analyzed, or in the books specifically for pupils or teachers in grades four, five, and six, which were analyzed, or were judged by the writer to give, in more detail, descriptions of the laboratory activities, together with the specialized materials needed, indicated as necessary in the attainment of an understanding of the principles and generalizations discovered as objectives. All of the courses of study and books which were analyzed were numbered.

In this analysis two kinds of statements were obtained. In the first place a list of statements of relationships—generalizations—which are used as objectives either for the pupils or as more ultimate objectives toward which the teaching should be directed consciously by the teachers but concerning which the pupils themselves are to be, for the present, unconscious. In the other type of analysis, statements were obtained indicating the activities used in the development of the objectives listed or used in making the important words in the generalizations more meaningful, in the performance of which some sort of specialized material facilities are indicated. All statements were placed on 3 x 5 cards, one statement on each card. At the beginning of each statement was placed the number of the course of study or book, from which the statement is taken. At the end of each statement was placed the page in the course of study, or book, in which the statement is found.

From this basic material four different classifications, on four different sets of cards emerged. The cards in one set have on them the statements of generalizations which are classified according to the type of interaction indicated. It is postulated in this study that the interactions among the fundamental elements of the universe, or aggregates of different size and complexity of these elements, are of sufficient importance to justify using such interactions as a basis for classification. The general principle used in the organization of the statements of interactions is to begin the organization by statements of interactions among large and complex aggregates and proceed in the analysis to smaller and simpler ones. Another set of cards has generalizations stated as words or phrases and these are classified alphabetically. Such words as photosynthesis, gravity, and friction make up this classification. Still another set of cards represent an alphabetical classification of materials, either equipment or supplies, used in the activities. Finally, another set of cards are classified alphabetically according to the activities carried on with the materials used. These four sets of cards have references from one to the other in such a way that one may go from a verb, such as *making*, to the various things made and the materials used in making them, and from the materials on up to the objectives to which such activities by the use of such materials contribute. On the other hand, one may start with any kind of material, either equipment or supplies and, by going one way in the analysis find the various uses or activities to which it may be put and, by going the other way in the analysis, find the various objectives to which it may contribute. One may also, of course, start with any statement of interaction and by going up in the analysis find the larger generalization to which it contributes; by going the other way in the analysis one finds the smaller generalization, if any, that contribute to the one under consideration. One can also go from any generalization to the

activities and material facilities, if any, which may possibly be used in its development.

This is a type of basic and detailed curricular material for a limited field so organized that many different problems may be solved by its use. If one wants to find the number of times that any piece of material is used in the analysis, he needs only to count the cards classified under this heading. If one wishes to find different things that can be done with any piece of material he finds in the analysis all the various possible uses that may be made of it. If, on the other hand, it is desirable to find the different objectives toward which a certain piece of material may contribute, one needs only go up in the analysis from the article under consideration to the objectives.

TABLE I

Items of Equipment and Supplies

Name of Article	*No. of Times Mentioned*
1. Animals	100
2. Aquaria	112
3. Bacteria	75
4. Bottles	200
5. Boxes	75
6. Bunsen burner	250
7. Candles	125
8. Cardboard	87
9. Charts	75
10. Cloth	100
11. Corks	75
12. Dishes	100
13. Dry cells	75
14. Plates of glass	75
15. Glass tubing	225
16. Glass tumblers	100
17. Jars	75
18. Lantern slides	75
19. Leaves	75
20. Magnets	75
21. Pans	100
22. Paper	125
23. Pictures	175
24. Plants	175
25. Ring stand	100
26. Rubber stoppers	150
27. Rubber tubing	87
28. Salt	75
29. Sand	75
30. Seeds	100
31. Soil	175
32. Test tubes	175
33. Thermometer	100
34. Water	400
35. Wire	75
36. Wood	175

Different criteria for the selection of materials needed for any particular course, if within the limits of this study, may, of course, be set up and on the basis of these criteria the material may be easily and quickly found from the basic curricular material here described. Since the writer is at present concerned primarily with the rooms, service, and furnishings needed in teachers colleges in the training of these intermediate-grade teachers, he can get some insight into what is needed by a study of the frequency of use of the materials in the analysis and what they are used for. This will certainly give evidence as to the major provisions that are needed in the way of rooms, service, and furnishings.

In this analysis there were 24,000 items of either equipment or supplies which emerged, 2,337 of which were different items. Table I gives a few of the items that appeared most frequently.

On the card with each one of the materials listed above in Table I is also listed the other items of material that are necessary to be used along with the item in the performance of the activity designated. Reference is also made to the various activities that are performed with the materials. From the word "animal" references are made to turtles, fish, tadpoles, toads, ants, bees, squirrels, protozoa, and rabbits. Other items referred to are aquaria, plants, compound microscopes, animal cages, boxes, pans, water, pipettes, battery jars, food, forceps, bottles, corks, hay infusion, glass jars, glass slides, pictures, specimens, and samples of fur. By following out references from each specific animal a more detailed list of other materials which may be used with each animal is found.

From this short list of materials that are found to be most often emerging in the analysis that has been described, one can see that provision should, most likely, be made for keeping various kinds of animals. If animals are kept they must have cages, food, tables on which cages are kept, aquaria, etcetera. If Bunsen burners are used, gas must be supplied as well as tables on which to work. If charts are used, provision must be made for storing charts, hanging charts, and very possibly making charts. If lantern slides are used, electrical outlets must be supplied, as well as a lantern, a screen, and darkening shades. If sand and soil are to be kept, there must be soil bins provided for storing them. If water is so necessary, the room must be supplied with running water, with sink facilities, with drainage facilities, and with some table space on which water can be used, without spoiling the table top. If plants are to be grown, provision must be made either in the science room itself or in a separate growing room. At any rate, soil, growing beds, flower pots, watering facilities, drainage, etcetera, are necessary in order that plants may be kept. Let us now consider briefly the type of data that are revealed by a little study of the set of cards at the foot of the list which deal with activities.

TABLE II
ACTIVITIES

Activity	*No. of Times Mentioned*
1. Collecting	75
2. Demonstrating	25
3. Examining	75
4. Growing	50
5. Keeping (caring for)	100
6. Making	800
7. Measuring	50
8. Observing	50
9. Planting	100
10. Showing	150
11. Testing	100
12. Using	800

There are 5,400 activity cards. On these 5,400 cards there are represented 277 separate activities. Table II gives a few of the activities that emerged most often.

TABLE III
INDICATING EQUIPMENT AND SUPPLIES THAT WERE BEING LEFT OUT IN ROOMS OR ON TOPS OF CABINETS IN ROOMS

Name of Article	*No. of Rooms in Which it Was Found Not Stored*
1. Bottles	15
2. Battery jars	12
3. Ovens	6
4. Charts	10
5. Models	6
6. Mounted animals—often birds	15
7. Aquaria	12
8. Preserved museum specimens	6
9. Flasks	7

From such an analysis there appear the activities that are most often called for and references from these activities indicate in each case the materials that are needed to perform the activity. Just as materials in the classification may be on different levels of use as when, for example, some materials are used in experimental activities; so activities are on different levels also. Such activities as sawing, nailing, bending glass tubing, etcetera, are often subordinate activities to such activities as making and using. If, however, a larger activity is decided upon as necessary, the smaller ones that make possible the larger one must also be considered.

In the writer's study of seventeen teachers colleges to see what rooms, service, and furnishings are being used in the training of intermediate-grade teachers in science evidence is at hand which indicates that it would seem to be desirable for many teachers colleges to give more attention to the curricular materials now being used in the intermediate grades and to use this information as a basis for better provisions for more appropriate rooms, service, and equipment to be used in this professional

training. In many cases teachers colleges do not have adequate furnishings, in the way of storage space for the materials they do have. One type of evidence for this conclusion is given in Table III, which gives some of the materials that were found unstored and for which, in so far as the writer could determine, there were not proper storage facilities.

A brief summary of the points made in this paper includes the following:

1. Specialized material facilities for science teaching have been assumed to be quite important in the teaching of science.

2. If laboratory activities are necessary in the training of teachers of science in the grades, attention needs to be given to the rooms, service, and furnishings needed to carry on these activities.

3. Laboratory activities should proceed from the science curriculum; equipment and supplies should proceed from the activities; and specialization of rooms, service, and furnishings should proceed from the equipment and supplies needed as well as the activities in which the equipment and supplies are to be used.

4. The chief purpose of laboratory activities is to give meaning to the generalizations that are most useful in life. An important contribution of laboratory work is to give meaning to the language symbols that make up the generalizations.

5. Generalizations—statements of interactions between fundamental phenomenal units or aggregates of these units or elements—are most useful in the selection of the desirable reactions to situations.

6. Generalizations deemed most useful in the intermediate-grade science can be found from an analysis of the material, such as courses of study and books, written for pupils in intermediate-grade science.

7. These generalizations can be classified according to the types of interactions, using the principle of starting with the interactions between rather large and complex aggregates of fundamental elements and proceeding downward to statements of interactions between smaller and smaller aggregates.

8. The analysis reveals the laboratory activities together with the materials needed in making more meaningful these generalizations. These activities give meaning to words as well as to the generalizations as wholes. While the generalizations selected serve as guides to the words that must be given meaning, generalizations can not be ranked as of greater importance than words because without words that are meaningful the generalizations are impossible. Before sentence generalizations can be made the language symbols, that is, words, must be made meaningful.

9. Laboratory activities do not generally reveal the meanings that will serve as guidance for the entire reactions to the complex situations which we meet but generally reveal meanings for important elements in the reactions to the very complex total situations in life.

10. From a preliminary analysis of these data we see that in planning the science rooms, service, and furnishings needed in the training of intermediate-grade science teachers, consideration must be given to the provision of electrical outlets, gas, lighting, hot and cold water, abundant table space with various specialized features, to storage and display facilities, and to sufficient floor space to provide for the extra space taken up by these specialized furnishings.

11. There is need in teachers colleges for attention to the selection of the laboratory activities needed in the professional training of intermediate-grade teachers, for more attention to the necessary equipment and supplies needed to make these activities possible, and finally for more attention to the rooms, service, and furnishings necessary for the use of the equipment and supplies needed in the laboratory activities decided upon.

THE EFFECT OF A SHORTENED CLASS-PERIOD UPON ACHIEVEMENT IN HIGH-SCHOOL PHYSICS

H. W. DUEL
West High School, Minneapolis

Teachers are often perturbed because their class-periods are shortened for athletic games and other extra-curricular activities. Many of them believe that this curtailment of time will have a serious effect upon the achievement of the students in their classes. The purpose of this experiment was to study the effect of shortening the class-period upon the achievement of students in high-school physics. The study was carried on at West High School, Minneapolis, during the interval from March 11 to April 10, 1935. In this school there are six class-periods during the school day. Ordinarily, these periods are 54 minutes long, with the exception of the first period, which is 58 minutes long. There are two fourth periods; one is preceded by a one-half hour lunch period; the other is followed by a one-half hour lunch period. This arrangement made it possible to shorten the fourth period for the physics classes from 54 minutes to 24 minutes by excusing the students in the fourth-period classes during both lunch periods.

Two hundred and eight students were involved in this study. Of this number, Teacher A had 98 students in four classes, which met during the third, fourth, fifth, and sixth periods; Teacher B had 110 students in four classes, which met during the first, second, third, and fourth periods. The subject matter covered consisted of the mechanics of liquids, the mechanics of gases, and molecular physics. The lecture-demonstration method was used for the laboratory work. Teacher A performed all the laboratory exercises for both his classes and Teacher B's classes. Achievement was measured by means of an objective test of 75 items scaled according to McCall's T-score technique.[1] This test was given at the beginning and at the end of the experiment. From the scores in the initial test (OT_1) and the final test (OT_2) the achievement of the students, in terms of gains [illegible] determined.

Teacher A's fourth-period class contained twenty-one students, for 18 of whom complete records were available. These 18 students were paired with 18 students in Teacher A's other three classes on the bases of I.Q.'s and scores in the initial test. These pairs are shown in Table I. Teacher B's fourth-period class contained 32 students. Complete records were available for 30 of these students. These 30 students were paired with 30 students in Teacher B's other three classes on the two bases mentioned above. These pairs are shown in Table II. Statistical treatment of the data shows no significant differences in means or variabilities between the two groups in Table I or the two groups in Table II, with respect to the critera used for pairing.[2]

The usual school conditions prevailed during the interval of this study. There were interruptions for auditoriums and other extra-curricular activities, but the number of such interruptions was neither more nor less than might ordinarily be expected during a like interval at any time during the school year. Conditions in all classes were kept as constant as was feasible, with the one exception that the fourth-

[1] W. A. McCall. *How to Measure in Education.* New York: The Macmillan Co., 1922. pp. 272–291.

[2] With the exception of one girl in Teacher A's fifth-period class, one girl in Teacher B's first-period class, and three girls in Teacher B's fourth-period class, the students involved in these comparisons were boys.

period classes had a 24-minute period; the other classes a 54 or 56-minute period.

The results of the study are shown in Table I and Table II. In Teacher A's classes, these data show an average gain made by members of the pairs in the third, fifth, and sixth-period classes of 1.4 points in excess of the average gain made by the members of the pairs in the fourth-period class. In Teacher B's classes, this advantage was reversed. The members of the pairs in the fourth-period class made an average gain of 2.2 points more than the average gain made by the members of the pairs in the first, second, and third-period classes. Neither of these differences is statistically significant.† The advantage in Teacher A's classes of 1.4 points in favor of the third, fifth, and sixth-period classes may be due to factors other than length of class period. However, if this advantage is due to the length of the class period, one period more than twice as long as another resulted in only 9.7% $\left(\frac{1.4}{14.4}\right)$ more gain. When we consider how rapidly high-school students forget their knowledge of subject-matter, this small advantage seems an inadequate return for the additional half-hour per day spent in the classroom.

Another method of comparison is to consider the gains made by members of the separate pairs. The data for Teacher A's classes show that in seven pairs, students in the fourth-period class made the greater gains; in eleven pairs, students in the third, fifth, and sixth-period classes made the greater gains. The corresponding data for Teacher B's classes show that in twenty pairs students in the fourth-period class made the greater gains; in seven pairs, students in the first, second, and third-period classes made the greater gains; in three pairs, both students made the same gain. Here, again, an advantage in Teacher A's classes, in favor of the third, fifth, and sixth-

TABLE I

Comparisons Based on Eighteen Pairs Formed on the Bases of I.Q.'s and Scores on the Initial Test

Teacher A's Classes

Period 4					*Periods 3, 5, and 6*				
No.	*I.Q.*	*O.T.*$_1$	*O.T.*$_2$	*Gain*	*No.*	*I.Q.*	*O.T.*$_1$	*O.T.*$_2$	*Gain*
1	135	49	64	15	1	135	46	63	17
2	117	23	41	18	2	118	30	46	16
3	115	34	52	18	3	115	34	56	22
4	114	32	45	13	4	114	31	46	15
5	112	38	55	17	5	111	41	53	12
6	110	22	43	21	6	108	27	49	22
7	108	34	51	17	7	108	34	50	16
8	108	33	43	10	8	110	33	46	13
9	108	54	54	0	9	112	53	66	13
10	107	36	39	3	10	107	35	50	15
11	105	32	51	21	11	103	32	45	13
12	105	31	45	14	12	102	30	40	10
13	103	28	47	19	13	102	28	50	22
14	102	36	49	13	14	104	38	38	0
15	102	24	41	17	15	102	23	46	23
16	102	17	35	18	16	105	20	51	31
17	96	19	24	5	17	97	18	36	18
18	92	23	44	21	18	94	27	33	6
Mean	107.8	31.4	45.8	14.4	Mean	108.2	32.2	48.0	15.8
S.D.	9.35	9.25	8.65	5.85	S.D.	9.50	8.40	8.35	6.50

† The standard error of the first difference is 2.0 points; that of the second, 1.3 points.

period classes is more than offset by a larger advantage in Teacher B's classes, in favor of the fourth-period class. When Table I and Table II are considered together the data show that in 27 pairs the fourth-period students made the greater gains; in 18 pairs, the students in other classes made the greater gains; in 3 pairs, both members of the pair made the same gain. In other words, in 62.5% of the cases, students in classes which met for 24 minutes per day did as well as, or better than, students in classes which met for 54 or 58 minutes per day. The number of cases in this study was too small to indicate a preferential length of period for any particular level of intelligence.

The scope of this study was too limited to justify more than tentative conclusions. However, with respect to achievement as ordinarily measured, the findings indicate: first, that the 54-minute class period could be shortened a considerable amount without any serious loss to the students; second, that the effects of an occasional shortening of the class period are negligible.

TABLE II

Comparison Based on Thirty Pairs Formed on the Bases of I.Q.'s and Scores on the Initial Test

Teacher B's Classes

Period 4					*Periods 1, 2, and 3*				
No.	*I.Q.*	*O.T.*$_1$	*O.T.*$_2$	*Gain*	*No.*	*I.Q.*	*O.T.*$_1$	*O.T.*$_2$	*Gain*
1	136	38	62	24	1	130	41	64	23
2	127	28	60	32	2	132	28	58	30
3	121	33	53	20	3	121	36	55	19
4	118	41	52	11	4	120	36	58	22
5	115	44	45	1	5	115	45	53	8
6	115	24	52	28	6	112	21	30	9
7	114	32	56	24	7	115	30	50	20
8	114	21	58	37	8	112	19	49	30
9	114	32	46	14	9	115	36	56	20
10	113	33	55	22	10	113	35	51	16
11	113	38	60	22	11	113	38	55	17
12	113	31	49	18	12	110	27	51	24
13	112	32	48	16	13	112	28	44	16
14	112	36	50	14	14	111	39	42	3
15	112	38	65	27	15	114	38	52	14
16	112	34	49	15	16	112	36	52	16
17	112	32	60	28	17	111	36	61	25
18	111	30	53	23	18	110	32	52	20
19	109	27	55	28	19	112	24	52	28
20	109	28	50	22	20	108	23	59	36
21	107	31	51	20	21	108	28	39	11
22	107	23	54	31	22	105	21	46	25
23	107	32	60	28	23	107	31	50	19
24	106	33	53	20	24	106	32	46	14
25	104	36	53	17	25	105	34	51	17
26	103	20	36	16	26	104	21	34	13
27	100	20	52	32	27	100	23	51	28
28	99	32	58	26	28	100	27	50	23
29	97	21	37	16	29	100	27	39	12
30	94	28	36	8	30	96	30	47	17
Mean	110.9	30.9	52.3	21.4	Mean	111.0	30.7	49.9	19.2
S.D.	8.67	4.95	6.80	7.60	S.D.	7.85	7.00	7.70	7.80

BUILDING A NATURE TRAIL AS A SUMMER SCHOOL PROJECT

HAZEL SEGUIN
State Teachers College, Superior, Wisconsin

As a summer school project our Junior High Science Group chose to build a Nature Trail last summer. This took us out-of-doors to study nature in its natural habitat. This meant for each child real experience with living things. It meant many hours working out in the sunshine—hours of work which seemed like play because every bit of the work of building the trail was a true pleasure to every child, and I might add, to all who watched the children at work.

Before we started actual work on the trail, we talked it over and decided that we'd like to build a Nature Trail which would give pleasure and information to everyone in the school, from the kindergarten to the college students. By the response that we received to our efforts when our work was completed, we felt that we had done a real service to all the school and community. I also felt that the children had enjoyed their work more and learned more than I had ever even hoped for. The children all agreed that it had been such "fun" and I felt from the attitude of each child in the group and also of each visitor to our trail, that our project had served to build a greater appreciation and respect for the out-of-doors. What more can they ask us to do—when they ask us to teach conservation in our schools? By inviting all of the grades in school and their friends in the community to journey down our trail after it was finished, we felt that we were sharing our information with everyone. No age was barred. There was something of interest to everyone from the kindergarten child to the college student.

The first step in the building of the trail was to plot its course. We had only the six weeks' summer session in which to complete our project and therefore our trail couldn't be too long. After making a thorough survey of our school campus, we decided that there was much of interest very near at hand. We laid our plan to encircle our Training School building and also the parts of the college campus which were planted in native shrubs and trees. We were very fortunate because our college ground's committee has seen to it that there is at least one specimen of every native Wisconsin tree and shrub growing on our campus. So our "Nature Museum" was all ready for us to work on. All we had to do was to lay the trail, gather information about the plants and label them in an interesting way. Then people would be more than ready to journey with us down our trail and look with us through a new vista opening to them a world of knowledge, creating life interests, happy hobbies and myriads of ways to use leisure time and incidentally an appreciation of our new emphasis on conservation.

After the plan for the trail was laid, we set to work to build it. This meant labeling the trees, shrubs, weeds, and flowers along the path. It meant constructing cages for the animals which we found along the trail. In order to label these things we had to find out what they were and do quite a bit of research before we could make labels for them. Our room became a nature library full of all the books on plants and animals that were suited to our level of comprehension. We spent two hours each day in research, working in groups, identifying and finding out all that we possibly could find on the plants and animals along our trail. Finally we sifted this information until we had a few pertinent statements which would be suitable for our labels.

We were not interested only in labeling the names of our trees and shrubs. We wanted to tell the visitors to our trail more than that. Following are a few of the labels we prepared for the plants along the trail:

We made cages for our insects out of screening and cheese cloth. The piece of screen was sewed in a cylindrical shape and the pieces of cheese cloth sewed around both ends and gathered together in the center

COMMON LILAC
(Syringa vulgaris)

As early as 1652 this shrub was the modest ornament of many cottage yards. When emigration set westward the lilac was the first flowering plant that bloomed by the side of the log house in the frontier settlement.

The lilac moved on until it reached the regions of long, hot, dry summers. There it could not grow.

ENGLISH ELM
(Ulmus campestris)

The wood of this elm is hard, heavy and has a fine grain.

In early times, before cast iron was discovered, the wood of the English Elm was used for water pipes because it was very durable.

Your arms are opposite each other. So are the branches of this Maple.

LOMBARDY POPLAR
(Populus Nigra italica)

This poplar can do two things. It can make a narrow leafy wall sooner and more satisfactorily than any other tree and it can grow by the roadside and not shade the road.

GOLDEN CURRANT

Under natural conditions this shrub would grow much higher. Its stunted growth is due to the fact that it is being crowded out by the more sturdy shrubs.

WOODBINE OR VIRGINIA CREEPER
(Psedera quinquefolia)

Notice how this vine creeps. It has tendrils at the tips of its branches. It affixes itself to the stone by enlarged terminal adhesive disks. This is how it is able to climb so high.

In a small square on any lawn or field you can find many plants. Here are a few.

TIMOTHY OR HERDS' GRASS
(Phleum pratense)

Found in all meadows. Timothy is commonly cultivated for hay.

DANDELIONS

These may be killed by sprinkling them with a solution of 1 lb. of iron sulphate to 1½ gals. of water.

This will burn your grass for a short time, but the grass will come back in better shape than before the treatment.

Iron sulphate should not be more than 10¢ a pound at a drug store.

QUACK GRASS
(Agropyron repens)

This weed is one of our worst enemies because it is so hard to control.

Just a small piece of the root will produce a new plant.

It is a perennial plant and so it grows from year to year.

COMMON PLANTAIN
(Plantago major)

This is a common weed of our lawns. The best way to get rid of it is to dig it out or apply iron sulphate solution.

It blossoms in June and produces thousands of seeds. Each seed is one-twentieth of an inch long.

so they could easily be opened and closed. These were hung up on trees and shrubs along the trail. We made screen and wood box cages for our turtles, frogs, salamanders, snakes, toads, etc. These cages were placed in the shade, under the trees and shrubs.

Following are some of the labels we prepared for our animal cages:

POTATO BUGS
(Colorado Beetles)

Originally this bug was found feeding on plants of the potato family, in Colorado. It gradually made its way East, traveling from potato patch to potato patch.

DRAGON FLY
(Anax junius)

This insect darts back and forth with swift well-controlled motions. It scoops up its game in a "basket" formed by its six extending legs and the front of its thorax.

ANTS

Some ants can carry a weight 6 or 7 times their weight, over a distance 300 times their own lengths, up a steep incline and over many obstacles.

An ordinary man, to compete with this would have to carry 1000 lbs. up stairs one-tenth of a mile in length.

LEOPARD FROG
(Rana pipiens)

This frog is our friend because he eats flies. Watch and you will see how he catches them.

FACTS ABOUT SNAKES

1. It is true that some snakes "play dead" as a means of protection. The hog-nosed snake is an example.
2. It is true, as a rule, that snakes cannot strike more than ⅔ of their own length.

FICTION ABOUT SNAKES

1. It is not true that snakes are able to charm birds and people.
2. It is not true that there is such a snake as the Hoop snake, which takes its tail in its mouth and rolls like a hoop.
3. It is not true that snakes are slimy.

We used Dennison's linen tags and waterproof India ink for our labels. These were tied on with raffia. All of this material was rainproof and kept in good condition until the end of our project.

When our work had been completed, members of our group were stationed at intervals along the trail, to welcome visitors and to answer any questions about the plants and animals which they might like to ask. Because of our hours of research, each member of the Science group was full of information and very anxious to impart his knowledge to anyone who came to listen and learn. They were very proud children when the visitors journeyed down their trail!

HOME-MADE APPARATUS FOR AN AUTOMATIC FIRE ALARM

W. G. WHITMAN

State Teachers College, Salem, Massachusetts

Construction projects appeal to many students—to those with keen minds and also to those who, perhaps, excel more in manual than in mental ability. Wherever laboratory facilities are available for extra-curricular activities there are usually students eager to take advantage of the opportunity. For such students or for a group in a science club the making of an automatic fire alarm presents an interesting problem.

Stimulate the club first to think of possible ways to have the heat from a small fire cause a bell to ring. The group discussion brings out the suggestion that some means of having the heat from the fire close an electric circuit is needed. *How can this be done?* Different methods may be proposed. If there is no agreement on one best method have the sponsors of different methods each apply the method he thinks best.

Perhaps the simplest method suggested is also the easiest to make. It is that of separating the strips of metal by a thin disc of paraffin. The pieces of metal are under tension so that when the paraffin melts they will spring into contact and close an electric circuit in which an electric bell is connected. The thin disc of paraffin may be prepared by letting a drop of melted paraffin fall upon a stone laboratory table. Many students will devise ways of setting up this equipment. The hot air from a burning candle or match will set off the alarm.

Automatic heat control is so common now that pupils will think of thermostats and of mercury circuit closers. Suppose a group decides upon a home-made compound bar and a mercury switch. Since this combination is more complicated than the device merely using a circuit kept open by a film of wax, it will be described in greater detail. However, it is suggested that pupils should not be told definitely "what" or "how" until they have exhausted their own resources in the exercises of their own inventive ability. Study of tables of coefficients of expansion discloses the fact that the expansion rates of iron and zinc—two easily obtained metals—vary a good deal.

The Thermostat.—The iron is cut from an ordinary "tin" can and the zinc is taken from the roofer's scraps. Cut the two pieces exactly the same size, say 4″ to 4½″ long, and 1/3″ to ½″ wide. They should be perfectly flat. Coat one side of the "tin" strip with solder as for sweat soldering. Clean one surface of the zinc with steel wool. Sweat solder the zinc and "tin" strips together. Care must be taken not to apply a direct hot flame to the zinc else it will melt. Use heat enough on the "tin" to melt the solder and warm the zinc until the two are soldered tightly together.

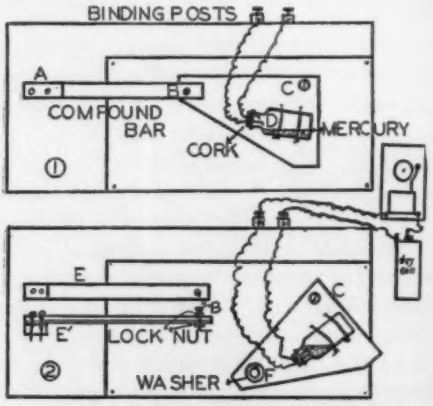
The Support.—The wood support may be about 7″ by 3″, and to remove the friction of the falling switch may have the front, or at least one-half of it, covered with bright smooth metal. At the top of the wood support are two binding posts. Do not have the metal covering come very near the top, because a short circuit will result if it touches the binding posts.

The Switch.—The switch for closing the circuit consists of a small pill vial 1″ to 1½″ long. The bottle contains a small amount of clean mercury. Two wires held by a tightly fitted cork extend into the bottle. The ends at D are bare. This makes the gap in the electric circuit which will be closed by tipping the bottle so that the mercury covers the ends of the wires. Plenty of slack wire runs from the bottle to the binding posts. The wire must be flexible and insulated, about No. 22 or No. 24.

The bottle is wired to a sheet of heavy copper or galvanized iron which is about 1/16" thick. Near the end of this metal, a washer, F, is soldered. The upper inside of the washer is filed to round it so that the end of a screw used to hold it up may release it at the slightest movement. A smooth drop of solder is fastened on the back of the metal opposite the washer. A hole, C, is made for support.

Assembling the Parts.—Study of the diagrams will show how the parts are assembled. The compound bar has an adjustable screw (*B*) placed in one end fastened by lock nuts. The other end is firmly screwed to the support through a block of wood which holds it one-half inch away from the support (see *E*). Let the pupils decide which side of the compound bar should be on the outside. The switch is supported at *C*, so that the screw, *B*, engages the rim of washer, *F*. The screw, *B*, is adjusted so that when the compound bar is cold the blunted point of the screw just holds the switch up, but when warm it releases it. The switch should swing with perfect freedom. Place a washer on the pin, *C*, back of the metal, and see that the switch will fall with practically no friction when not supported by *B*.

By holding a lighted match or a small candle flame several inches below the thermostat, the bar will release the switch, and as the circuit is closed the bell will ring. It



is more impressive if the bell is connected by long wires, so that the alarm is given at a considerable distance away from the fire.

A GROUP-INDIVIDUAL PROJECT IN REFRACTION

W. E. Stirton
Cass Technical High School, Detroit, Michigan

In the teaching of Physics, perhaps more than in any other branch of Science, there are many opportunities for the instructor to provide individual student assignments whose solutions will provide a stimulus and challenge to the better students. At the same time these projects can be of such a nature that their results will be of real tangible classroom value, not just a "busy work" project to consume student energy.

In preparing a large number of this type of assignment, the author has been under the common handicap of having large classes. This means less time available for the correcting of papers and it also means that the possibilities of student collusion or copying is greatly increased. So the project must be of such a nature that it can be presented to a large number of students simultaneously, assigning different values to each student, still its solution must be easily and readily checked by the instructor. Here is a typical problem that in my experience meets all these requirements.

Let us assume a man wishes to start from a point A (shown in the figure) and walk to point B. In so doing, he has to walk through a meadow, where he can travel four miles an hour and a marsh, where his speed is reduced to two miles per hour. The line of demarcation between meadow and marsh is assumed a straight line. The distance of point A from this line of separation is called

X in the figure, and a different value of X is assigned to every student. The question asked is, "What is the path from A to B that requires the least possible time?"

The method of solution as indicated to the student is as follows: Calculate the total time required for all the nineteen different paths produced as the distance called "M" varies from 0 to 18 miles by unit steps. Then plot these values of total time as ordinates against the values of "M" as abscissae. Make this curve to as large a scale as the graph paper will permit and from this curve read that value of "M" for which total time is a minimum. This undoubtedly will not be a whole number value of "M" if the curve has any degree of accuracy. Record this particular value of "M" (called M′) in the report. Then the student is asked also to evaluate this ratio $R=\frac{M'D'}{N'C'}$, where M′ is his unique value, N′ the corresponding lateral distance, and C′ and D′ the corresponding distances in meadow and marsh.

The student, then, is asked to turn in

(1) The graph of M as abscissae against total time as ordinates.

(2) A tabular exhibit on the back of the graph paper in a form as shown to demonstrate his derivation of the graph.

M	*N*	*C*	*D*	*Time in Meadow*	*Time in Marsh*	*Total Time*
0						
1						
⋮						
18						

(3) On the graph indicate the value of "M" he determines as the value M′.

(4) The evaluation of the ratio $R=\frac{M'D'}{N'C'}$.

When the instructor checks, all that is really necessary is to mark the value of R. For reasons discussed below, it should be exactly 2, no matter what value of X was assigned to the student, though every student's values for M′, N′, C′ and D′ will be different. If it is desired to check further, there can be available a graph constructed by the instructor showing the relationship between M′ and the different possible values of X. Then the students' determination of M′ can be checked against this curve.

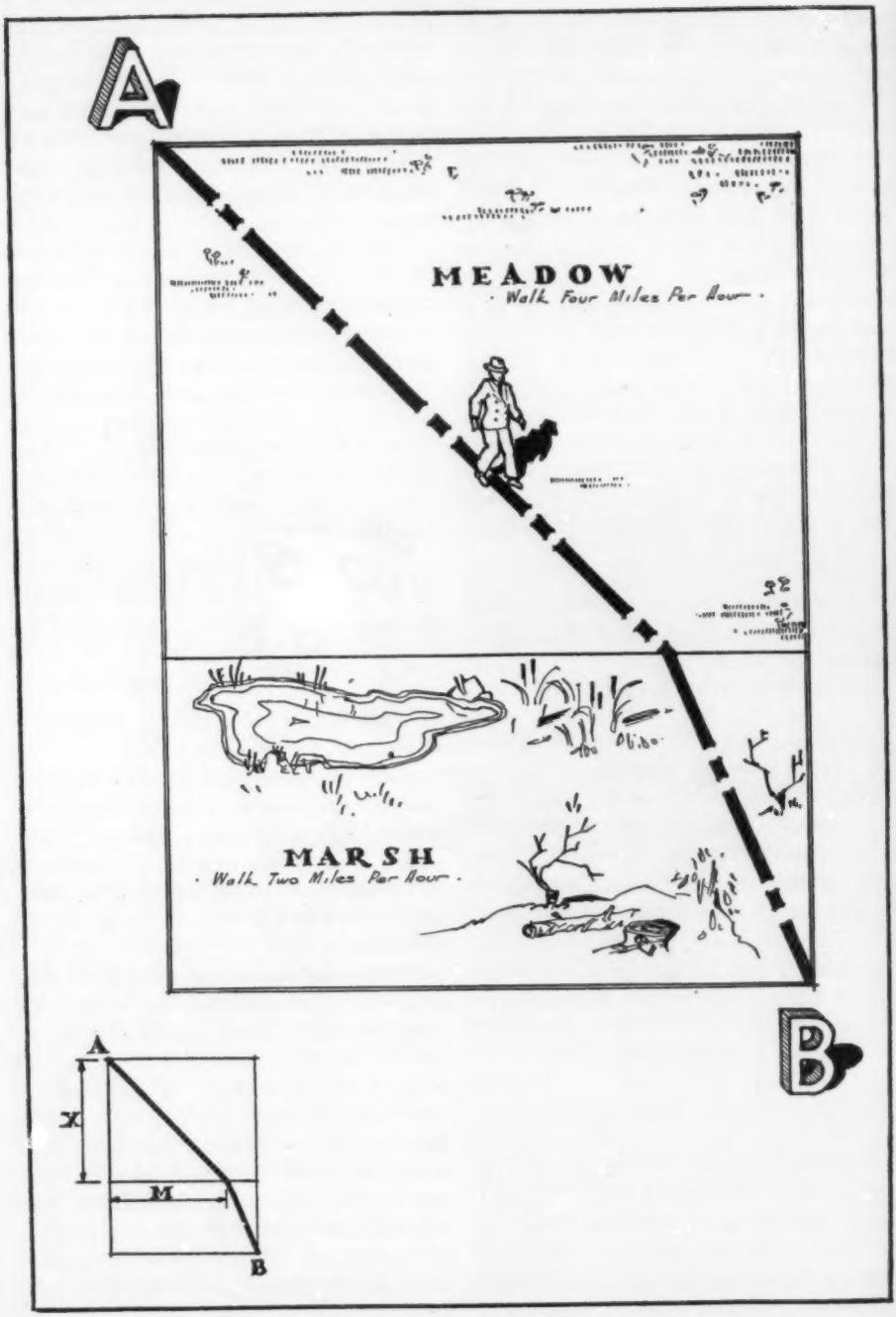
The interpretation of the problem as a teaching asset of course lies in the fact that it explains *why* light bends the way it does in passing from a less dense to a more dense medium. Light chooses that path which requires the least time and, therefore, the least energy. I am not aware of any high school text, which points out this answer to the question of *why* light bends the *amount* it does in passing into a medium of a different density.

The ratio asked for can be shown to be the index of refraction. In optical terms $\sin i=\frac{M'}{C'}$ and $\sin r=\frac{N'}{D'}$ and $R=\frac{\sin i}{\sin r}=\frac{M'D'}{N'C'}$. And, since the index must be the ratio of the two velocities, in this particular case it must be $4/2=2$.

For the exceptional students it is worth while to point out to them that what they have actually done is to graphically differentiate the equation of time of travel from A to B, and, as in the calculus, set down derivatives equal to zero and solve for the minimum value.

Perhaps for the instructor's sake it may be worth while to add a few explanatory remarks. The graph paper usually available in the school bookstores is 18 cen × 24 cen. That is the reason M was made to vary between 0 and 18. Using paper of these dimensions, locating A in one corner of the paper and B in the diagonally opposite corner, and calling the distance from the top of the paper to the line of separation of meadow and marsh X, then the equation showing the values of M for which the total time is least is as follows:

$$432x^2+m^2x^2-48mx^2+16m^2x+m^4-36m^3+132m^2=0.$$


A
MEADOW
· Walk Four Miles Per Hour ·
MARSH
· Walk Two Miles Per Hour ·
B
A
X
M
B

It is to be noted that this equation, while of the fourth degree in M, is only of the second degree in X. So the instructor in constructing his graph, with which to check values of M′, can assign values of M in the equation, solve the resulting quadratic in X, and plot the real values of X as abscissae against values of M as ordinates.

It might be suggested that this entire procedure can be varied from year to year by varying the original procedure. In this case give each student identical values of X, but an individually different value for the velocity in the meadow. On this basis the same question can be asked, the same valuable principle demonstrated, and the same simple check made on the students' work though the check graph, if used, must obviously be set up from a different equation. Assuming $X = 12$, with the same kind of graph paper, and calling the velocity in the meadow V_1, in the marsh still two miles per hour, the equation for plotting the checking graph is most conveniently stated as follows:

$$V_1 = \frac{2M}{18 - M}\sqrt{\frac{M^2 - 36M + 468}{M^2 + 144}}.$$

Assign values of M, solve for V_1, then plot V_1 as abscissae against M as ordinates.

MOVABLE DIAGRAMS

L. F. Pinkus
St. Louis Public Schools, St. Louis, Mo.

In general science and physics, one is accustomed to use sectioned models, wall charts, textbook illustrations and, at times, discarded parts of engines to explain and demonstrate the action of gasoline engines and the like. Most of these procedures are somewhat expensive and the late economy drives make it highly desirable to find a substitute for these methods. In a new school none of the usual materials were on hand with the exception of the textbook illustrations. However it was possible to secure a motion picture of the gasoline and steam engines for classroom showing, and from this came the idea of movable diagrams. Groups of students were arranged to carry out the various diagrams along the lines of the excellent charts shown in the films.

Gasoline Engine. The students were given a 24 by 36 inch heavy cardboard on which the cross section of the gasoline engine was drawn in outline. Then we cut the piston, valves, connecting rod and crank from cardboard of the same thickness. The piston, connecting rod, and crank were then fastened together with notebook pins and placed in the proper position on the diagram. The cylinder walls were built up with an additional narrow strip of similar weight cardboard and a slightly wider strip pasted on top of the walls acted as a guide for the piston and held it in place when the diagram board was vertical. The valves were handled in a similar manner. With this diagram, it was possible in the course of explanations, to move the piston in its various positions and show the opening and closing of the valves in proper sequence. The parts were painted in contrasting color and labelled. The materials for this project are inexpensive and it has proven helpful in clarifying the principles of the gasoline engine.

Steam Engine. The success of the gasoline engine project suggested the use of a similar diagram for our study of the steam engine. However in this project, the diagram was improved by the use of laminated wood for the cylinder, steam chest, piston rod, sliding valve and valve rod. The stationary parts, the cylinder and steam chest, were pasted on a large heavy cardboard. The valve and piston were properly placed and held in position by means of a cross piece at the stuffing box. As in the

first project, the various parts were labelled and painted. Here again, the project proved helpful; the movable piston and valve were used during discussion to illustrate the action of the steam engine and the relationship of moving to stationary parts.

The same diagrammatic method was used to dramatize the principle of the two-cycle gas engine, Diesel engine, D. C. generator and D. C. motor. In the teaching of the physical principles, the diagrams were a valuable demonstration aid and also the projects were successful in stimulating the interest of the students to individual effort. A few students prepared their own small-scale diagrams on notebook size cardboard to accompany their reports. It is felt that others will find this project helpful and may also find various other diagrammatic possibilities along this line for demonstrating physical principles.

A PIONEER PASSES

Dr. Herbert Brownell, Professor of the Technique of Instruction in Science at the University of Nebraska, died of a heart ailment on September 15 at the age of 74. He had taught in Nebraska for forty-three years, and in the University for twenty-six years. He was Chairman of the Division of Secondary Education.

Born in Madison, New York, Professor Brownell graduated from the State Normal at Oswego, and Hamilton College. He taught in rural and urban schools, and was one of the first educators to study and write on special techniques of science teaching. He was on the staff of the Peru, Nebraska, Normal College for several years before becoming associated with the State University.

Dr. Brownell was a frequent contributor to educational magazines, and wrote four books: *Laboratory Lessons in General Science* (1916); *A First Course in Physics* (1929); *The Teaching of Science and the Science Teacher* (with F. B. Wade in 1925); *Physical Science: An Introduction to the Specialized Courses in College Science* (1931). At the time of his death he was revising *Physical Science* and had practically completed a companion manuscript on Biological Science. Another manuscript, a comprehensive presentation of the history, philosophy, and methods of science education, was also receiving his final reading.

In celebration of his thirty-first anniversary as a teacher in Nebraska, his fellow-members of Phi Beta Kappa gave him a dinner, and presented him with a life membership in the National Education Association. On this occasion a voluminous collection of letters from his former students was presented in bound form. It was an inspiration to this writer to read, at a later date, these expressions of appreciation, and the tributes to a guidance that was professional, personal, and in no small measure spiritual. Since Dr. Brownell's classes were large, the measures of his influence on the teachers of a wide area, over more than two generations, could hardly be over-estimated. He considered these letters as representing the chief remuneration for his labors as a teacher.

Dr. Brownell was sage, philosophical, practical. He sensed humor quickly. He used analogies and illustrations liberally in writings and lectures. He was poised and calm, yet never cold. Although he had participated in the practices of science education even before the turn of the Twentieth Century, nevertheless he understood and accepted all that was modern and at the same time sound in pedagogy.

Dr. Brownell is survived by his widow, four daughters, three sons, and nine grandchildren. His death is the first in this large family circle. His life was long, rich in both professional and personal achievement, and a genuine factor in several decades of educational progress.

—H.A.W.

Editorials and educational news

SCIENCE FOR ADJUSTMENT

It is generally admitted that our present offerings in school science have not yet been processed into an integrated content of activities of greatest value in general education. Basic philosophies of science education, in harmony with a basic philosophy of general education, need to be formulated and tested to provide the foundation for the program of science teaching.

It is here proposed to state very briefly one philosophy of science education which may merit consideration.

The human organism is in constant interaction with his environment, both as an individual and as a member of the social group. In this interaction he is faced with making adjustments. Some of these adjustments are of the nature of overt activities; others are merely intellectual or contemplative. Science, as attitudes, methods of solving problems, and knowledges, may aid the individual in making these adjustments. In fact, many of the adjustments call especially for science for the reason that so much of the modern environment is a product of the applications of science.

EDITOR'S NOTE: *In the October, 1935, issue of the journal we invited our readers to submit for publication in this section expressions of views relating to significant aspects of science education. A number of challenging statements have appeared. We again extend this invitation to the end that the journal may become an open forum—on the problems of teaching science. In this and in forthcoming issues there will appear a number of editorials in which members of the editorial staff present fundamental philosophies of science education. It is hoped that these statements will elicit reactions from our readers and, consequently, will add to the value of this section of the journal.*

It, therefore, would seem to be true that our science work in the schools, aimed at general education, should find its problems, its content, and its results in the problems of human adjustment and not in the pure science of a generalized or a specialized nature. Further, it would appear that, for the laymen, those adjustments which are of the nature of overt activities, such as attaining comfort, producing and consuming the essential materials for life, achieving efficiency and safety in living, maintaining health, using and controlling energy in its various manifestations, and, in general, dynamic living as a worthy member of a social group, are of greater significance than are those adjustments which are merely intellectual.

If our school science courses can be formulated primarily in terms of these real problems of human adjustment, rather than in terms of the facts or principles of this or that branch of pure science, we may hope (a) that science education may take a prominent place in general education through enabling children and adults to live more completely and more profitably in the complex modern environment, (b) that the science work may be coordinated functionally with the work in other fields of the school curriculum, and (c) that the problems for study in science will provide a basis for studying science in the spirit of science and thus yield those attitudes and methods which are so essential in facing the real problems of adjustment in a modern world.

—C. J. P.

SCIENCE TEACHING AT THE CROSSROADS

Some recent committee reports and courses of study in science education reflect a point of view and philosophy of science teaching which, if generally accepted and followed in all of its implications, may lead into conditions that are in many ways analogous to those from which science education is just emerging after a long period of ineffectiveness and decadence.

A hundred years ago science teaching in America was aimed toward the immediate needs of boys and girls in the living of a rich and full life. Turn through the pages of any of the books published about that time and it is possible to see this philosophy reflected from cover to cover in the direct approach to the subject, in the simple, homely, illustrations, and in the emphasis on the practical aspects of the subject. That science teaching did attain this objective to a considerable degree is attested by the large enrolments in most of the high school sciences offered at the time.

The year of 1872 produced the memorable Harvard Descriptive List of physics experiments and ushered in an era of science teaching characterized by the domination of the colleges, the formalizing of instruction, and the loss of interest by students in the sciences offered. For more than four decades science teaching struggled under the confining shackles of this domination which emphasized content values to the neglect of the practical and immediate needs of the learner.

With the publication of the report of the Committee on the Reorganization of Science in Secondary Schools, in 1920, it seemed that the period of college domination was about at an end and that a new and more promising era for science teaching lay ahead. In this publication we see attention again directed toward the learner of science, his needs and his interests. Practical outcomes as well as intellectual are set up as worth while goals in an attempt to secure a more balanced and well-rounded individual. Other learning experiences than reading and experimenting are proposed. But probably the most significant aspect of this report is its complete break from the content-centered formalism of the preceding four decades and the setting up of objectives which had real meaning for the boys and girls who studied science in the classroom. That the point of view and proposals of this bulletin have had widespread influence on science teaching is revealed by the recent survey made by Beauchamp and reported as a portion of the National Survey of Secondary Education.

The years since the Great War have been chaotic. On every side the youth we teach has been buffetted by confusion, distress and failure. Change is apparent on every hand. Politics, religion, economics, every aspect of modern life is in a condition of flux. We in science education believe that many of the ills of the present might be circumvented, or in part alleviated, if people in general could effectively use the scientific method of solving problems, and could attain more of a scientific attitude toward life in general.

Science teaching is at the crossroads. Science teachers must decide upon the basic philosophy that will guide their offerings to a confused and bewildered younger generation. There are two alternatives: (a) a science in which emphasis is placed on experiences that are vital both as they aid in adjusting to present life and as they train in methods of solving problems that may be met in later life or (b) a science which in its emphasis on formal content as major generalizations may repeat in this decade the calamity of 1872. The one a forward-looking dynamic philosophy; the other a throwback of more than fifty years.

Let us as a group of teachers interested more in what the content does to the student than in what the student does to the content, pause at the crossroads and then move ahead. Let us make no left or U turns.

Ellsworth S. Obourn,
John Burroughs School

SCIENCE COURSES ARE FOR THE BOYS AND GIRLS

The history of science education in our schools has been marked by the wrecks of attempted science organizations that have been built to carry young people on toward adult goals of scientific training. This has been the story of the teaching of practically all of the special sciences in high school and early college years. Physiography has gone. Only remnants of botany and zoology have survived. Formal physiology is almost uniformly detested. Physics has been loosing ground for many years. Chemistry has stood still. The more recently organized courses in general science, general biology, and the survey courses in college have helped to stem the tide for two reasons: (1) They have been required of many young people in the schools; (2) They have dealt with applications, topics, problems, and activities of more immediate concern to the boys and girls enrolled in them.

Now we are facing a renewed danger of a possible loss of interest in training in science fields by our youth in high schools. This danger arises from the efforts of workers in science education to find a formula built of abstractions about which to set up the patterns of school courses in science. These abstractions are expressed as principles, major generalizations, concepts, training in scientific method, or the development of scientific attitudes.

There is no doubt that the formulae expressed in terms of these abstractions make logical centers for course construction from the adult point of view, or from the point of view of ultimate social worth. The difficulty lies in the fact that teachers lose sight of the learning experiences through which individuals must reach such abstractions, and center attention upon an attempt to have pupils learn the abstractions with little meaningful experiential setting.

In other words, human beings do not learn through very direct experiences with abstractions. It is even possible that there are large numbers of human beings for whom such abstractions as a major generalization, a scientific method, or a scientific attitude will never have any meaning. And yet these people live in a present world of science and must learn to get along in it.

We learn largely through contacts with things, phenomena, or problems of direct and immediate concern to ourselves. It is exceedingly doubtful if very many of us are very much concerned with abstractions as such. Science courses to be successful must present a possibility for a rather large number of experiences that will help young people interpret applications or phenomena about them. The problems must be problems of definite application, not vague questions of general concern. "How can I keep the roses in my garden from dying of blackspot?" *not* "How are plant diseases prevented?"

At present we know very little about the more useful experiences that might produce in young people desirable types of science training. It is probable that for a given type of training there are fifty, or more, desirable learning experiences. At present we need an increased emphasis upon the educational problem of finding worth while applications and problems of science that are of definite concern to young people in our existing world. We need a wide range of experimental trial of the learning value of these experiences. Finally we need an accumulation of reports upon such experimentation in the literature of science teaching.

Ralph K. Watkins,
University of Missouri

MINUTES OF THE NINTH ANNUAL MEETING OF THE NATIONAL ASSOCIATION FOR RESEARCH IN SCIENCE TEACHING

St. Louis, Missouri. February 23, 24, 25, 1936
Headquarters: Hotel Statler

The dinner meeting was held on Sunday evening, February 23rd, at six-thirty o'clock. Those in attendance included the following:

Bayles, Ernest	Hethershaw, Lillian
Bedell, Ralph	Johnson, Palmer O.
Billig, Florence	Laton, Anita D.
Blough, Glenn	Mayfield, John C.
Cahoon, G. P.	Noll, Victor H.
Caldwell, Otis W.	Obourn, Ellsworth S.
Carpenter, H. A.	Pieper, Charles J.
Craig, Gerald S.	Powers, S. Ralph
Cunningham, Harry A.	Robertson, Martin L.
Davis, Ira C.	Roecker, William F.
Gruenberg, Benjamin	Thiele, C. L.
Hall, Jennie	Watkins, Ralph K.
Havighurst, Robert J.	Webb, Hanor A.
Heiss, Elwood D.	Whitman, Walter G.

The meeting was called to order by the President, Gerald S. Craig. The first item of business was the report of the Secretary-Treasurer, S. R. Powers. The reading of the minutes of the meeting in Atlantic City (February 1935) was dispensed with for the reason that they had been distributed to the members by mail. The report of the Treasurer, which is included herewith, was read and approved.

The next items of business were the reports of committees.

1. The reading of the minutes of the Executive Committee was dispensed with for the reason that they had been distributed to the members by mail. The minutes were approved.
2. The report of the Committee on Constitutional Revision. Following the requirements of the Constitution, this Committee prepared and distributed by mail to the membership the proposed revisions of the Constitution. The revisions as proposed were adopted and the Committee dismissed. (A copy of the revised Constitution and By-Laws was sent to members.)
3. The report of the Committee on Rotation and Tenure of Office. This Committee, working in cooperation with the Committee on Constitutional Revision, had submitted its recommendations to the latter Committee. These recommendations were included in the proposed revision of the Constitution and were adopted in adopting the report of the Committee on Constitutional Revision. The Committee was dismissed.
4. The report of the Committee on Publications was submitted. It was regularly moved and seconded that the report be adopted and included in the minutes sent to members. A copy is on file in the secretary's office. It was regularly moved and seconded that Parts I and III of the report be referred to the Editor of Science Education for his consideration; that Part II be referred to the Committee of Five; and that the Committee on Publications be continued with instructions to develop further the program suggested in Part IV of the report.
5. The following report of the Committee Cooperating with the Committee on the Place of Science in Education of the A. A. A. S. was submitted and approved.

   The Chairman reported for the Committee as follows:

   In view of the fact that the A. S. T. A. was initiated at Boston in 1933 and tentatively organized in Pittsburgh in December 1934, and was finally organized in St. Louis with duly elected officers, and having had presented a proposed constitution, it is our judgment that the N. A. R. S. T. accept the invitation of the officers of the A. S. T. A. to become an affiliated organization. This recommendation by the Chairman was made as a motion which was seconded by Dr. Ralph K. Watkins.

   It was pointed out that the proposed constitution of the A. S. T. A. provides that to become final it must be approved by the first five charter affiliated organizations. By this means the question of affiliation dues for each official representative on the Board of Directors is subject to approval by these charter affiliating organizations.

   After considerable discussion it was moved and carried that the problem be referred to a committee consisting of the retiring President of the N. A. R. S. T., the President of the A. S. T. A., the President of the Department of Science Instruction of the N. E. I., and the President-elect of the N. A. R. S. T., for further consideration and recommendation.

   This committee met as instructed with Mr. Whitman acting as Chairman. After considerable discussion the committee voted to recommend that the N. A. R. S. T. affiliate with the A. S. T. A. This recommendation was presented at the next business meeting of the N. A. R. S. T. and approved.

   Harry A. Carpenter,
   Chairman.
6. The report of the Committee to Draw up a List of Active Investigators in the Field of Science Education was approved and the Committee continued. The list has been sent to members.
7. The report of the Program Committee, as mailed to members, was approved and the Committee dismissed.
8. The Committee on Resolutions made a preliminary report and asked permission to report again at the Monday meeting. This permission was granted.

The dinner meeting adjourned at 10:00 P. M.

The second session of the ninth annual meeting was held on Monday morning, February 24th, from 8:30 to 11:30.

The meeting was carried out as indicated on the printed program. The report of the Committee of Five was given which included reports of its sub-committees. The Chairman of the Sub-committee on Scientific Attitudes was not in attendance at the meeting. The reports as given were accepted and the Committee of Five, with its various sub-committees, was continued. (Some of the sub-committees of the Committee of Five submitted mimeographed reports. These are not included in the minutes. Members who wish these reports and who were not in attendance at the meeting may get them by addressing the committee chairmen. The sub-committees with their members are listed later in these minutes.)

The other items on the program were presented as printed.

Business Meeting

1. Election of Officers for 1936–1937. The report of the Nominating Committee, consisting of Harry A. Cunningham, Chairman, Ralph C. Bedell, and W. L. Eikenberry, was as follows:

President, W. G. Whitman.
Vice-President, Ira C. Davis.
Secretary-Treasurer, S. R. Powers.
Members at Large of Executive Committee, G. S. Craig and Hanor A. Webb.

This report was accepted and the nominees declared unanimously elected.

2. The report of the Auditing Committee, consisting of Ellsworth S. Obourn, Chairman, Glenn Blough, and Hanor A. Webb, was approved and accepted. This report was mailed to members.

3. The further report of the Committee on Resolutions was submitted and adopted and the Committee dismissed. A copy of this report was sent to members.

The meeting adjourned at 11:30 A. M.

The third session of the ninth annual meeting was held on Tuesday, February 25th. The program was presented as outlined in the printed program.

The session adjourned at 11:30 A. M.

Minutes of the Meeting of the Executive Committee

The Executive Committee consisting of the officers for 1935–1936 met on Sunday, February 23rd. Those in attendance were Gerald S. Craig, W. G. Whitman, S. R. Powers, and Ira C. Davis.

The Secretary reported that as a result of the nominations at the meeting in Atlantic City, seventeen individuals were nominated by the Executive Committee and these were approved for membership by a majority vote of all the members. This vote was conducted by mail. Ten of the seventeen accepted membership. These are:

Ernest E. Bayles
Glenn Blough
G. P. Cahoon
Fred P. Frutchey
Philip G. Johnson
Lillian Hethershaw
Leo Hadsall
J. H. Jensen
John C. Mayfield

Two nominations were made for 1936–1937. These were: Herbert J. Arnold, Assistant Professor of Natural Sciences, Teachers College, Columbia University, and W. H. D. Meier, State Teachers College, Framingham, Massachusetts. It was voted that these names be sent to the membership for vote.

The President appointed an Auditing Committee consisting of Ellsworth S. Obourn, Chairman, Glenn Blough, and Hanor A. Webb.

The second meeting of the Executive Committee consisting of the officers for 1936–1937 had a luncheon meeting on Monday, February 24th. Those in attendance were: W. G. Whitman, Ira C. Davis, S. R. Powers, G. S. Craig, and Hanor A. Webb. The business consisted of appointments of committees and discussion of some matters of policy.

The following *Constitutional Committees* were appointed for 1936–1937:

1. Program Committee: Martin L. Robertson, Chairman; Ralph C. Bedell; Bertha Parker; S. R. Powers, Ex-officio.
2. Publications and Editorial Committee: Elwood D. Heiss, Chairman; John A. Hollinger; Robert J. Havighurst; Charles J. Pieper.

Special Committees:

The following changes were recommended for the Committee of Five: To separate the Committee on Scientific Attitudes from the Committee of Five with instructions to continue work with the same membership as during 1935–1936. Add to the Committee of Five, Benjamin Gruenberg to represent the field of adult education, Dr. Gruenberg to be instructed to select two other members to constitute a Sub-committee on Adult Education. Action was taken concerning the appointment of Palmer O. Johnson as a member of the Committee of Five and as Chairman of the Sub-committee on Junior College Science to take the place of Ralph W. Tyler. Dr. Tyler resigned from the chairmanship of the sub-committee on junior college science but accepted a place on this sub-committee. The Committee of Five would then consist of Ralph K. Watkins, Chairman, Florence G. Billig, Ellsworth S. Obourn, Palmer O. Johnson, and Benjamin Gruenberg.

The Sub-committes of the Committee of Five are as follows:

a. Committee on the Education of Teachers: Ralph K. Watkins, Chairman; Frank C. Jean; George W. Haupt; H. A. Cunningham.

b. Committee on Elementary School Science: Florence G. Billig, Chairman; W. G. Whitman; G. S. Craig; W. W. McSpadden; Bertha M. Parker; M. L. Robertson; Wilbur L. Beauchamp; Ellis Persing; E. Laurence Palmer; Jennie Hall; Glenn Blough.
c. Committee on Secondary School Science: Ellsworth S. Obourn, Chairman; Fred G. Anibal; George W. Hunter; Ernest Bayles; John C. Mayfield.
d. Committee on Junior College Science: Palmer O. Johnson, Chairman; Ralph W. Tyler; F. L. Fitzpatrick; Archer W. Hurd.
e. Committee on Adult Education: Benjamin Gruenberg, Chairman; two other members to be selected.

Ralph C. Bedell was named a Committee of One to study and report possible activities in the field of science.

There was some discussion at the time of the meeting. It was proposed that the dinner meeting be changed to Saturday evening and that consideration be given to the possibility of a joint meeting with the National Council of Supervisors of Elementary Science. No definite action was taken on this. President-elect Whitman will assume responsibility for investigating the possibility of making this change. His recommendation will be submitted to the membership at a later time.

The following changes in the By-Laws were made:

Section 1. The President shall be Chairman of the Executive Committee and shall preside at all meetings and be ex-officio member of all committees.

Section 2. The Vice-President shall preside at all meetings in the absence of the President.

The members of the Executive Committee approved the request of Dr. Noll that the Committee to Draw up a List of Active Investigators in the Field of Science Education be allowed $25.00 for expenses.

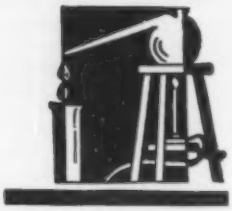
The resignation of Herbert Brownell was accepted.

TREASURER'S REPORT
February, 1936

Balance—February, 1935	$487.14	
Received dues for 1935:		
64 members at $5.00	320.00	
Received late dues for 1934:		
3 members at $5.00	15.00	
Total		$822.14
Expenditures		
To A. G. Seiler for printing programs of Atlantic City meeting (1935)	$15.30	
To C. M. Pruitt for 70 subscriptions to SCIENCE EDUCATION	140.00	
Total		155.30
		$666.84
Interest		5.43
Balance—February, 1936		$672.27

Respectfully submitted,
S. RALPH POWERS,
Secretary-Treasurer.

Abstracts



GENERAL EDUCATION

A Symposium: Evaluation of Theory and Practice. "Evaluating the Intangibles," by Marvin L. Darsie; "Evaluation by the Modern Secondary School Teacher," by J. Murray Lee; "Pupil-Teacher Partnership in Measuring Progress," by Ethel Percy Andrus; "Appraisal of Educational Outcomes in Secondary Schools," by Grayson N. Kefauver; "Measurement and Evaluation in Secondary Education," by D. Welty Lefever; "Advancements in Appraisal at the Junior College Level," by George H. Meredith and M. E. Bennett; "An Experimental Program on Marks and Report Cards," by George H. Pence and A. T. Newman. *California Journal of Secondary Education* 11: 275–298; May, 1936.

This series of articles on an important phase of secondary education is worthy the attention of all who are interested in problems of high-school teaching. —F.D.C.

FRUTCHEY, F. P. "Testing for Application of Scientific Method." *Educational Method* 15: 427–432; May, 1936.

The article points out that during the past ten years there has been a decided shift in point of view in teaching, from an emphasis on subject matter to an emphasis on the development of children. In many science courses, the use of the scientific method is an important objective. Teachers in the 30 schools of the Eight-Year Study of Progressive Education have stated a number of aspects of scientific method. Several of these are listed in the article. Problematic situations to test some of the stated aspects of scientific method, as carried out in several schools, are described. —C.M.P.

The Evolving Curriculum of the Secondary School: "Some Criticisms of the Conventional Secondary Curriculum," by T. M. Riley, and "Characteristics of a More Adequate Secondary Curriculum," by William B. Brown. *California Journal of Secondary Education* 11: 305–312; May, 1936.

The first of these two articles discusses "Subject Matter Set Out To Be Learned; The Pre-Mass Education Curriculum; Transfer of Training; Mental Discipline and 'Vested' Interests; Atomistic and Organismic Psychology; Development of Tests and Testing; Unemployment; Higher Age Limit for Compulsory Attendance; Satisfying Use of Leisure Time; Character Formation; Changing Types of Employment; Changing Social Order; Individual Differences; College Domination, and The Laggard Senior High School." The second article discusses the following problems: "How Do We Define Core Curriculum and How Much of the Pupil's Time Should Be Given to It?" "How Are Individual Needs and Interests Adequately Provided For?" "From What Sources Should These Core Experiences Be Drawn?" "What Should Be Excluded from the Core Curriculum?" "What Should Be Emphasized in the Core Curriculum?" —F.D.C.

TYLER, RALPH W. "Defining and Measuring Objectives of Progressive Education." *Educational Research Bulletin* 15: 67–72; March 18, 1936.

Progress made in evaluating or appraising the programs of the thirty schools in connection with the Eight-Year Study is reported. The task of clarifying educational objectives is very important and difficult. Several exploratory procedures are being tried out to perfect more definite instruments of appraisal, especially for the less tangible outcomes. —C.M.P.

HARBESON, JOHN W. "The Nature and Functions of the Forward-looking Secondary School." *California Journal of Secondary Education* 11: 137–142; March, 1936.

The author first discusses the nature of the forward-looking secondary school—its scope, its curriculum, its extra-curricular activities, its guidance program, and its social emphasis. He then discusses these functions of the forward-looking school: "To develop a citizen actuated by a sound philosophy of life." "The development of a citizen capable of working out his own highest self-realization." "The development of a citizen capable of functioning in a democratic society." The author closes with these significant statements: "If we want to turn out citizens from our secondary schools capable of functioning in a democratic society, they must acquire this experience in the secondary school. Secondary schools of this character will be ex-

pensive, but they will be worth all they cost. It is they, and not our armies, that alone can make the world safe for democracy." —F.D.C.

Symposium: "Integrated Education in Lincoln School." *Teachers College Record* 37: 363–447; February, 1936.

The following phases of the integrated educational program of Lincoln School of Teachers College are discussed: (1) Integration in the Lincoln School Philosophy, by Lester Dix; (2) Life in the Elementary School, by Rebecca J. Coffin; (3) The Arts in the New Curriculum, by Alice Schoelkopf; (4) Leisure in the New Curriculum, by Ouida R. Meyer; (5) Life in the High School, by John R. Clark; (6) Integration in the Junior High School, by Frances G. Sweeney; (7) Integration in the Senior High School, by L. Thomas Hopkins; (8) World Literature, by B. J. R. Stolper; (9) American Culture, by Edwin S. Fulcomer; (10) Foreign Languages at Lincoln School, by Frederick J. Rex and Jane E. Brown; (11) Guidance in the Lincoln School, by Gertrude H. Hildreth; (12) Curriculum Development, by L. Thomas Hopkins, and (13) Science in the Junior High School, by H. Emmett Brown, Hubert M. Evans, and N. Eldred Bingham. —C.M.P.

McCall, William A. "How Wide is the Gap between Principle and Practice?" *Teachers College Record* 37: 603–606; April, 1936.

Evidence is accumulating that the gap between principle and practice is much wider than has generally been supposed and is too wide to justify much of the teacher training given in normal schools and teachers colleges. Principles, to be of real help, must be embodied in functioning procedures. Little by little, in certain areas, the gap is being bridged between principle and practice, precept and example. —C.M.P.

Kelly, Frederick J. "Junior Colleges and Social Reconstruction." *The Junior College Journal* 6: 427–433; May, 1936.

This interesting article closes its discussions of the various phases of the problem indicated in the title with this summary: "The junior college which will function best in this period of social reconstruction is one characterized by these six statements: (1) It must be distinctly a community institution; (2) it must be intimately related to the high school in its program; (3) it must be genuinely hospitable to vocational education; (4) it must so organize the community resources that abundant leisure life shall be participated in by most all the youth, particularly the unemployed ones; (5) it must be the center of an adult education program; (6) it must achieve such a measure of social intelligence among its students that they can play their part in moving toward greater and greater cooperation." —F.D.C.

Webb, Paul E. "Analysis of Junior College Offerings." *The Junior College Journal* 6: 339–344; April, 1936.

The significant discussions in this article are summed up thus: "The small junior colleges are facing a dilemma: on the one hand their curricula, when judged in the light of minimum desirable standards, are inadequate to serve the purposes (preparation for advanced work) for which they were designed. On the other hand, the number of students enrolled in the courses of these curricula is insufficient to make possible the maintenance of classes of a desirable minimum average size. Any increase in offerings (a necessary step for the attainment of desirable standards) would so further reduce the ratio of enrolments to offerings that it would still further limit the possibility of maintaining classes of an acceptable average size. For the small junior college it would appear that an adequate preparatory offering and a desirable minimum average class size are incompatible. The solution calls either for an increase of enrolment or for an adjustment of the curriculum to less ambitious purposes. The first alternative implies the discontinuance of the small junior college; the latter, a reconsideration of the functions of the junior college." —F.D.C.

Witzemann, Edgar J. "The So-called Scientific Method and Its Rôle as a Process in Democracy." *Scientific Monthly* 43: 122–129; August, 1936.

The article sets forth the thesis that the scientific method is really the adaptation of an ancient method to a limited set of problems that come within the boundaries of what is traditionally called science. Supporting evidence to affirm this thesis is included. —C.M.P.

Kandel, I. L. "Secondary Education and Social Change." *The Kadelpian Review* 15: 347–355; May, 1936.

The author maintains "that the conflict which exists in educational circles today is not so much a conflict between conservatives and progressives, or between those who insist that the acquisition of enduring knowledge is still a desirable aim in education, and those who maintain that the function of education is not to teach what to think but how to think, as though the two can be separated, but between those who believe that education cannot be successful unless it builds upon and incorporates the best of the past, and those who talk about education for change." One reason for the weakness of American education is a certain tendency to build a structure without any foundations. The only basis for social life in a democracy is enlightenment. The school cannot be made responsible for social change. —C.M.P.

Floyd, Oliver R., Kinney, Lucien B., and Lund, Torsten. "The Unified Curriculum." *The Phi Delta Kappan* 18: 203–209, 218; March, 1936.

This article is an account of a comprehensive revision of the curriculum of the University of Minnesota Junior High School. The increase in the proportion of the population of high-school age in high school, the effect of the depression and changes in accepted psychology have been the main factors underlying the integration movement. Because social and economic problems cut across subject-matter boundaries the fixing of attention upon these boundaries has resulted in a disposition to depart from subject-matter divisions. The problem is not solved by weakening or destroying subject-matter boundaries. Fitting subjects together results at best in conventional materials presented in a somewhat revised order. At worst all essential organization is lost. The integration movement may be criticized for failure to appreciate the values of the orderly classification of knowledge into special subject-matter fields. Also programs are set up which do not properly recognize the specialized preparation of teachers. There can be no substitute for sound scholarship. Teachers need to be so well grounded in their subjects that they may be in a position to see the relationships of their specialties to other subject fields and to society. To secure this result the teacher's specialized training must be supplemented by a much broader cultural background that is now usually possessed. A detailed outline of the University of Minnesota plan sets forth objectives, guiding principles, an example of how one of the seven areas is worked out, method of organization of teaching units, and evaluation. —O. E. Underhill.

Wood, Ben D., and Beers, F. S. "Knowledge Versus Thinking." *Teachers College Record* 37: 487–499; March, 1936.

The authors contend that thinking depends upon knowledge and facts—without these two there can be no thinking. They answer negatively the question, Can Teachers Create Thinkers? "Those who prefer thinking unfettered by facts display a deep fear of rote 'memory' and a militant suspicion of anything which even superficially suggests that remembering is not a criminal act. . . . The generalization that 'the purpose of the social sciences is to teach students to apply the principles and generalizations of the social sciences to new social problems' or 'to train students to deal with the problems of a changing civilization' seems to be an excellent example of an empty generalization—a verbal fetish whose futility thrives as the inevitable result of the cult of thinking that is largely and almost arrogantly unfettered by mere facts.—So far as a deeply sympathetic observer can see, social science teachers as a group are not notably distinguishable from other teaching groups in regard to citizenship. They are not ordinarily regarded as better citizens, or more unselfish in economic or social conduct, or as more intelligent voters, or as affording more and better leadership in social emergencies than other teaching groups." —C.M.P.

Spelman, W. B. "Personnel Service in Morton Junior College." *The Junior College Journal* 6: 414–418; May, 1936.

This topic is discussed by the author under the following sub-topics: "Establishment of Organization; Pre-Registration; Registration; Adjustments; Orientation to Junior College; Counseling Routine; Placement; Criticism." —F.D.C.

Lund, S. E. Torsten. "Why Is the High School?" *The Phi Delta Kappan* 18: 108–114; December, 1935.

In spite of increased high-school attendance, the curriculum has changed but little and is not meeting the need of the present high-school population. The changes in social and economic needs have been very rapid. Our present educational program has been hopelessly outdistanced. "The rate at which man has progressed in learning to subjugate the world of matter and energy . . . has increased almost geometrically. Technological advance . . . is so far ahead that no one is fully capable of appreciating its further implications to society. . . ." This analysis of the needs of the high-school pupil, with suggestions as to how they may be met, indicates the important function science may play in the process. The need for consumer education is stressed. The author is chairman of the science department of the University High School, University of Minnesota. —O. E. Underhill.

Jordan, A. M. "The Harmful Effects of All Propaganda and Their Avoidance." *The High School Journal* 18: 264–272, 284; December, 1935.

Facility in critical analysis which will enable the individual to make decisions on the basis of merit rather than because of the inference of slogans and other forms of emotional appeal should be a major objective of education. Our educative process has failed to do this. Propaganda defined as "willful distortion of facts" is analyzed under the headings "Propaganda during War Time," "Propaganda in the Business World" and "Propaganda in Social Control." Cogent examples of each type are given. The future citizen should be taught: (1) to develop self-critical attitudes through high-school courses and (2) the techniques of propaganda so that it may be recognized.

Previous mention is made of the experimental work being done by Biddle in attempts to mea-

sure the effect of specific procedures in counteracting the effects of propaganda.
—O. E. Underhill.

Benezet, L. P. "The Story of an Experiment." *Journal of the N. E. A.* 24: 301–303; 25: 7–8; November, 1934, and January, 1936.

The reviewer has been following with much interest this series of three articles. Although the experiment described is concerned with teaching arithmetic, there is much to interest the teacher of science. The lesson described in the first installment, dealing with the erosion at Niagara Falls, is good science as well as good arithmetic. The discussion of the contrasting methods of approach with regard to arithmetic applies equally to the teaching of science at elementary and junior-high-school levels. The difference between learning to think in terms of quantitative concepts, and learning to add, multiply, subtract, and divide is clearly indicated. It would be a service to science teachers if someone would describe similarly the difference between learning to think in terms of science concepts and learning to solve problems and manipulate scientific "laws" in terms of class-room procedures and pupil reactions.
—O. E. Underhill.

Davis, C. O. (Editor). "Some Innovating Practices among North Central Association Schools." *North Central Association Quarterly* 10: 427–436; April, 1936.

Several experiments in progress in the North Central Association schools are briefly described in this compilation. They involve class size, a plan of attribute or trait ratings, an orientation plan, guidance programs, a home room plan, a point system, curriculum and instructional changes, and correlations of school with community life.
—A.W.H.

ELEMENTARY SCIENCE

Blough, Glenn O. "Science in the Elementary School Program." *School Science and Mathematics* 36: 255–258; March, 1936.

The author develops these theses: "Generally speaking native tendencies and interests of a child should be developed and guided." "An important outcome desired in our elementary school is the development of an attitude of mental alertness and curiosity on the part of its pupils." "The ability to manipulate facts and data, in order to arrive at definite conclusions, is necessary to the growth of a child." "The ability to organize subject-matter, to suggest methods of learning it, and develop problems is highly desirable in the elementary school." ". . . subject-matter emphasis must shift from a purely academic point of view to the use of subject-matter for child growth."
—F.D.C.

Vinal, William Gould. "The School Camp Line-Up for Nature Education." *Clearing House* 10: 462–466; April, 1936.

The author discusses the following requirements as the ideal situation for nature education: (1) There must be correct food habits; (2) There must be sound sleep; (3) There must be sound sex attitudes: (4) Nature education best takes place where nature is; (5) There is no nature education without action; (6) Children should be given the opportunity to work in the laboratory of life; (7) There must be challenging new experiences involving play, work, and study groups; (8) There must be a variety of nature offerings; (9) Nature recreation is nature education; (10) Vital nature education requires good leadership; (11) The time is near at hand when all people will experience nature education in camp, and (12) What is ahead of us in nature education.
—C.M.P.

Palmer, E. Laurence. "Weight; Conservation; Save the Soil." *Cornell Rural School Leaflet* 29: 32 pages each. November, 1935, January and March, 1936.

These three useful Leaflets will be of value to both elementary science teachers and general science teachers. Several practical experiments are described and much worthwhile information is included.
—C.M.P.

Morrison, J. Cayce. "A Generalist Looks at Science in the Elementary Schools." *Teachers College Record* 37: 282–289; January, 1936.

The author traces the history of nature study and elementary science in the schools of New York State. Most progress has been made in the last five to eight years. There are still many obstacles in the way of developing an adequate elementary-science program. Criteria for the development of an adequate elementary-science program are listed. "Regardless of the type of school organization, science should receive as much emphasis in the elementary school as is now given to history, geography, or arithmetic."
—C.M.P.

Lauer, Dorothy. "Little Lessons in Nature Study." *The Grade Teacher* 53: 32–33; April, 1936.

This is an article appropriate for the intermediate grades. It describes the process of breathing in plants, budding, and grafting.
—C.M.P.

Smith, Helen A. "Spring Awakening." *The Grade Teacher* 53: 26–27, 68–69; April, 1936.

This is an article listing activities in elementary science for the primary grades. Activities include those relating to pussy willows, frogs, toads, pet rabbits, wild rabbits, bears, caterpillars, and turtles. —C.M.P.

Ball, H. R. U. "Children's Interests and Experience in Relation to Science." *The School Science Review* (English) 17: 321–330, 565–574; March and June, 1936.

This is the report of an investigation involving "some thirty classes in typical suburban and semi-suburban elementary schools." Some 6000 questions by 800 children were tabulated. Two thousand of the questions were classified. General questions about materials and machines totaled 22 per cent. "Children from eight to twelve, girls as much as boys, show great curiosity about physical facts. Although—perhaps because—they have been taught about living things, they ask twice as many questions about physical phenomena as about animals, and six times as many as about plants." Most of the questions involved "origin and how does it go (work, grow, change)?" Most of the children kept pets. Eleven per cent of the questions were about animals: (In order—origin; external differences; individual differences; cries; food, and locomotion; exceptional powers and behavior; usefulness, and growth.) Three out of every four children had a garden plot of their own. The collecting habit also seemed to be strong. "Curiosity also seemed to be especially strong in the child under eleven." —C.M.P.

SECONDARY SCIENCE

Krenerick, H. Clyde. "Method of Accomplishing Laboratory Work in a Single Period." *School Science and Mathematics* 36: 515–523; May, 1936.

This timely article presents many practical suggestions based upon extensive try-out in the classroom and laboratory. It offers much of value to "those who by force of circumstances or by decree have been, or may be, compelled to change from the double to the single period." —F.D.C.

Preston, Carleton E. "The Science Column." *The High School Journal* 19: 27–30; January, 1936.

This consistently excellent column discusses the function and value of laboratory work. Experiments too often are done to "prove" something. "Of course these experiments never really proved anything; they merely called attention to one or two illustrations or concrete applications. And when teachers led their students to believe they were actually proving things in this way they were allowing them to develop a very loose and inaccurate conception of what logical proof requires." The pupil should rather be sent to the laboratory to find out something. It may be to find out something that is already known to science, but it may be unknown to him, or it may be a step in a process of thinking, the emphasis being on the processes of scientific reasoning, planning and observing rather than on the correctness of some known physical constant. A pupil may be led to determine such a constant and to repeat his work in order to obtain a more correct value, but for the purpose of planning ways of correcting errors in method rather than for obtaining a result which is an end in itself. "Whatever the values ascribed to laboratory experimentation, there can be no doubt that it is too slow and expensive a method to employ merely for the pu.pose of imparting scientific information." —O. E. Underhill.

Preston, Carleton E. "The Science Column." *The High School Journal* 19: 57–59; February, 1936.

The discussion this month, "A New Departure in Curriculum Making," is centered on the new Virginia State curriculum. This departs radically in its core content from the traditional curriculum materials. "Traditional subject divisions have been largely broken down and replaced by wider and more integrated divisions of knowledge, within which content is selected, not that subjects may be adequately covered, but that the needs and interests of potential citizens may be adequately met." In this curriculum secondary-school science constitutes one of the four major contributing fields. There is much science in the elementary grades, it being very prominent in the third and fifth. Nowhere in this core curriculum is there reference to the conventional divisions of science into physics, chemistry, or biology. One of the defects of the traditional science curriculum which has been felt is that there is no opportunity for a regular growth through four years. Due to the fact that there are always some beginners in any science course together with others who have had two or three science courses, it is necessary to start at the elementary level suitable for beginners. One attempt to obviate this is a four-year general science course of progressive difficulty. Another is to increase the science through grades one to nine to the point where it is assumed to be sufficient as a minimum. The Virginia curriculum offers a third way of meeting this difficulty. —O. E. Underhill.

New University of Chicago Films: *Educational Screen* 14: 300–303; December, 1935.

The contents of each of the six reels comprising the new "Erpi" series, entitled "The Story of the Earth in Talkies," is briefly reviewed. The names of these films are "The Work of Rivers," "Ground Water," "The Work of the Atmosphere," "Geological Work of Ice," "Mountain Building," and "Volcanoes in Action." The content was prepared by Dr. Carey Croneis, of the University of Chicago. The photography includes scenes from three-fourths of the states in the Union taken by the National Parks Service, and bits of foreign scenes obtained from film libraries over the world. Pressure box, stream table and animated diagrams serve to speed up geographic processes, and aid in developing concepts otherwise incapable of visualization.

—O. E. Underhill.

Hinchley, L. C. "An Evaluation of Motion Picture Films for Class Room Use in Biology." *Educational Screen* 15: 8–9, 20; January, 1936.

Two biology films were shown to high-school sophomores and juniors. Test questions of the recall type were made, based on the films shown. These were given as a pretest and again immediately after showing the films. The discussion of causes and results is suggestive of factors which must be taken into consideration in using films as a teaching aid.

—O. E. Underhill.

Knox, W. W. "The Demonstration Method of Teaching Chemistry." *Journal of Chemical Education* 13: 166–171; April, 1936.

Although laboratories have been used by scientists for centuries, they have only within the last century come into use in teaching. The latter half of the 19th century witnessed a great development of laboratory instruction in science. Studies of the past fifteen years raise the question of the advisability of placing less emphasis upon individual laboratory experimentation and of employing more teacher demonstrations. The question is far from being settled, but the enthusiasts for individual laboratory work are faced with the necessity of proving their claims.

—V.H.N.

Hewes, Laurence Ilsley. "Butterflies—Try and Get Them." *The National Geographic Magazine* 69: 667–678; June, 1936.

The thrills, hardships, and techniques used in collecting and mounting butterflies are described in this illustrated article. —C.M.P.

Clark, Austin H. "Who's Who Among the Butterflies." *The National Geographic Magazine* 69: 679–692; June, 1936.

This article supplements the article by Hewes. Many different orders of butterflies are described. —C.M.P.

Stickles, W. Hugh. "Teaching General Science by Contract." *The Iowa Science Teacher* 2: 41–47; May, 1936.

This is the report of a three-year experiment in teaching general science by the contract plan. A summary of the advantages and disadvantages of the method is included. Advantages seem to outweigh the disadvantages. —C.M.P.

Fuller, Robert W. "Demonstrations or Individual Laboratory Work for High Schools." *Journal of Chemical Education* 13: 262–264; June, 1936.

A plea for the retention of individual laboratory work by the pupil in high-school chemistry classes. Teacher demonstrations have real values, especially with respect to economy of time and materials, but some very important outcomes of the study of science can be attained only through laboratory work. —V.H.N.

Aughinbaugh, B. A. "Some Common Causes of Damage to Slides and Films." *Educational Screen* 15: 10, 31; January, 1936.

The author, from his experience in directing a state visual aid service, gives information which will be helpful to those science teachers who, as is often the case, are expected to supervise the visual aid equipment of a school or city.

—O. E. Underhill.

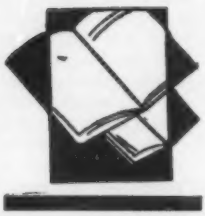
Hopkins, B. S., Mattern, L. W., Segerbloom, Wilhelm, and Gordon, N. E. "An Outline of Essentials for a Year of High-School Chemistry." *Journal of Chemical Education* 13: 175–179; April, 1936.

The outline consists of ten units as follows: Introduction; Dispersions; Chemical Change, Elements, Compounds and Mixtures; The Structure of Matter; Symbols, Equations, Weight Relation and Volume Relation; The Periodic Classification; Acids, Bases, Salts, and Ionization; The Nature of Non-Metallic Elements; Carbon, Carbon Dioxide, and Carbon Monoxide; The Nature of Metallic Elements; Organic Chemistry. The outline is intended to meet the needs of both college- and non-college-preparatory students. —V.H.N.

Symposium: "Geography in High School." *Journal of Geography* 35: 81–122; March, 1936.

This issue contains the following articles on high-school geography: "Political Geography in the High School," by Nels Bengston; "Teaching Geographic Relationship in World Problems," by O. W. Freeman; "Geographic Interdependence," by J. E. Switzer: "Geography in the Senior High School," by James F. Chamberlin; "Human Geography for the Senior High School," by J. R. Schwendeman; and "The Place of Geography in the Senior High School with Special Reference to Texas," by Edwin J. Foscue. —C.M.P.

New publications



CALDWELL, OTIS W., AND CURTIS, FRANCIS D. *Science for Today.* Boston: Ginn and Company, 1936. 755 p. $1.68.

Science for Today embodies in spirit and approach the scientific age in which we live. The selection of content and vocabulary is based on the findings of extensive educational research and experimentation by many investigators. The following reported investigations and writings were especially influential: (1) Curtis' *A Synthesis and Evaluation of Subject-Matter Topics in General Science;* (2) The *Thirty-first Yearbook* of the National Society for the Study of Education; (3) Thorndike's *Teachers Wordbook* of 20,000 Words; (4) certain unpublished studies by Curtis. There are fourteen units integrated by the energy concept, with a fifteenth unit devoted to scientific hobbies and activities for leisure time. The first chapter discusses science, what it is, and of what use it is. A list of sixteen scientific attitudes is included in this chapter.

Each unit is introduced by a preview. Each chapter has a preliminary "Questions this Chapter answers." A series of problems, self tests, experiments, additional exercises and activities, and a list of references constitute each unit. The organization, vocabulary, and selection of content are in keeping with the findings of psychology. Laws of learning such as interest, mind-set, exercise and so on have been practically applied. Thus the book should appeal to the teacher and to the pupil. Few, if any, general science books will excel it in teachability.

The authors have made a conscientious effort throughout the book to provide for training in the scientific method enunciated in the first chapter. The captions under the numerous well-selected pictures bring this out. For example, Figure 235, page 349, is a diagram of an oil well, showing the casing driven through the various strata down to the oil-bearing sands. The question, based on a major generalization for the unit, is "What evidence is here that 'The earth is very old?'" —C.M.P.

HEISS, ELWOOD D., OBOURN, ELLSWORTH S., AND MANZER, J. GORDON. *Our World of Living Things.* Books I and II. St. Louis: Webster Publishing Company, 1936. 343 p. $0.39 each.

These volumes represent a combined textbook, workbook, laboratory manual, and notebook for pupils in the high-school course in general biology. The books are bound in paper covers and are provided with spaces for notes and responses to questions and test items after the fashion of the typical workbook. Both books are necessary to complete the work of a year. The pattern of construction is like that of the previous general science books by Obourn and Heiss.

The point of view of the authors is that the biology course should integrate the biological materials of zoology, botany, and human physiology about a body of biological principles common to all forms of life. In attempting this they have succeeded well.

The whole course is set up in twelve units, six in each volume. Units deal with requirements for life, classification, food, interdependence, adaptation, response to stimuli, reproduction, heredity, improvement of plants and animals, conservation, and evolutionary change.

The structure of each unit includes a unit introduction, a set of unit problems, suggestions for study, the combined text and workbook materials, a summary of important ideas, a reference list and a test. There are also optional exercises and reading lists.

Text material built as these books are presents the advantages of an integrating of subject-matter and learning activities, and relatively low first cost. Disadvantages are the purchasing of new texts every school year, especially for those schools furnishing texts to pupils, and the limits set upon the amount of reading material that can be included within the limits of these books.

Biology teachers are encouraged to examine these books before adopting new texts for their courses. —R.K.W.

BLACK, NEWTON HENRY, AND CONANT, JAMES BRYANT. *New Practical Chemistry.* New York: The Macmillan Company, 1936. 621 p. $1.80.

This is not a revision of the authors' earlier *Practical Chemistry,* but a completely rewitten textbook with a similar name. In the estimation of the reviewer, it is much superior. This is true as regards the style, content, and illustrations. Stating as their philosophy that "the main purpose of the study of chemistry in school is to teach the scientific method" the authors present, in Chapter One, an excellent exposition of the scientific method. The authors have attempted to present examples of the scientific method throughout the book, with a constant emphasis upon the relation between chemistry

and social welfare and progress. At the same time, thoroughness of the study of chemical laws, facts and procedures has not been neglected. The fundamentals are presented in the first eighteen chapters and from the following eighteen chapters "selection should be made to meet local needs and interests."

The more recent advances in modern atomic theory are clearly and simply presented (although the authors recognize the inadvisability of making this presentation highly mathematical). The neutron is introduced and shown graphically as a part of the nucleus; the energy levels of the electrons, and the Balmer series are also included. Thus the authors assume a fairly well prepared teacher of chemistry in so far as a knowledge of fundamentals and modern atomic theory is concerned.

New Practical Chemistry is one of the best modern chemistry textbooks and undoubtedly deserves a wide usage. —C.M.P.

Furbay, John Harvey. *Curious Habits of Our Common Birds, Animals, and Plants.* New York: Noble and Noble, 1935. 254 p. $2.00.

Elementary science and biology teachers will be delighted to have this book as a supplementary reference book. Organized on a seasonal basis, there are fifty-two essays on interesting phases of nature. The titles of a few of these essays follow: (1) Autumn leaf colors; (2) Why the leaves fall in autumn; (3) Odors, what is their purpose; (4) Wasps, the first paper makers; (5) How insects spend the winter; (6) Strange facts about earthworms; (7) The home life of birds; (8) Curious things done by instinct, and (9) Curious foods of man.

Interesting poems are appropriately interspersed through the essays. A useful appendix is included on the preservation of plants and animals; how to make an insect collection; nature projects, and nature references.

—C.M.P.

Reed, Rufus D., and McLachlan, Robert W. *General College Chemistry for the Laboratory.* Montclair, New Jersey: Rufus D. Reed, New Jersey State Teachers College, 1935. 87 p. $1.80.

This is a laboratory manual in college chemistry the purpose of which is "to secure a high degree of correlation of laboratory, classroom, and library work in general college chemistry." The manual may be used in connection with any textbook.

The questions in the experiments are divided into two groups. In the body of each experiment are many specific questions so worded that they must be answered by the student on the basis of his own observation of experimental phenomena. In the supplementary exercises are questions which serve to train the student in the effective use of reference material. Experiments of Part I relate to the general field of chemistry while Part II presents a brief scheme of qualitative analysis.

Chemistry teachers in teacher-training institutions will find this manual more suitable to their needs than the usual liberal arts college laboratory manual. —C.M.P.

Howell, William H. *A Textbook of Physiology.* Philadelphia: W. B. Saunders Company, 1933. 1132 p. $7.00.

This is the twelfth revision of one of the most, if not the most, widely used textbooks in physiology. The first edition appeared in 1905. The fact that this is the twelfth edition attests to its usefulness and popularity. Science teachers of all levels will find it a most excellent reference. Its accuracy and authenticity is unquestioned, and the technical vocabulary has been kept at a minimum. Facts and theories have been presented with simplicity and lucidity.

—C.M.P.

Ditmars, Raymond L. *The Forest of Adventure.* New York: The Macmillan Company, 1933. 258 p. $2.50.

This is a travel "thriller" by the curator of mammals and reptiles of the New York Zoological Park. To those who have read his *Thrills of a Naturalist's Quest* and *Strange Animals I Have Known,* the mention of another Ditmars book is sufficient recommendation. This is another story of scientific exploration that will be eagerly read by thousands of young people and adults who long to go on such expeditions as make up the greater part of Ditmar's life.

While the author has taken certain liberties along fictional lines, and the members of the party originated in the mind of the author, the descriptions and facts are not exaggerated but have a scientific basis. The scenes of the story are the American tropics among the islands of the Caribbean and in Central America. What a thrilling time Morris, Albert, and Frank had—the envy of any boy who reads the book. And it will be difficult to forget Professor Smith too! —C.M.P.

Millikan, Robert Andrews, Gale, Henry Gordon, and Coyle, James P. *New Elementary Physics.* Boston: Ginn and Company, 1936. 637 p. $1.80.

This is a revision of one of the most popular and widely used secondary physics textbooks. The senior authors are well-known physicists and Mr. Coyle is Head of the Physics Department of the Lane Technical High School, Chicago.

The organization of subject-matter is the unit basis, being divided into the seven following units: (1) The properties of fluids; (2) laws of force and motion; (3) work and heat; (4) electricity and magnetism; (5) wave motion and sound; (6) light; (7) electronics and invisible radiations. This employment of the unit idea represents an advance step in secondary physics textbooks, yet the unit problem-solving technique

as it is being utilized in biology and general science textbooks is a stage to which the physicists have not as yet advanced.

This book is still on the old "mechanics, heat, sound, magnetism, electricity, and light" compartment basis. This does not wholly condemn the book for in the opinion of the reviewer it is the best textbook in the secondary physics field. It has many points to commend it. It is quite up-to-date, material being included on air-conditioning; the application of photoelectric phenomena to sound motion pictures, television, and picture transmission; the recent discoveries of the positive electrons, neutrons and cosmic rays; transmutation of elements, and the corpuscular or photon aspects of radiation. Social implications are emphasized and special attention has been made to eliminate vocabulary difficulties. There are 124 full-page illustrations and 555 illustrations. —C.M.P.

Huntington, Ellsworth. *Tomorrow's Children.* New York: John Wiley and Sons, Inc., 1935. 139 p. $1.25.

The subtitle of *Tomorrow's Children* is *The Goal of Eugenics.* The author is a research associate in geography at Yale University and well known for his *The Character of Races* and *Civilization and Climate.* This book is written in conjunction with the Directors of the American Eugenics Society.

Sometime ago the reviewer had occasion to do some research study in the field of eugenics, heredity, and genetics, and during the progress of the study many questions arose, the answers to which, often, were not easy to find, or when found, were more or less vague and intangible. And then along came *Tomorrow's Children* which very definitely answered many of the questions not previously answered or only vaguely so. For the individual desirous of a handy, authentic, useful book on questions and problems relating to eugenics, this book is recommended. There is nothing sensational about the book, but it does not gloss over the facts. Every phase of the problem of eugenics is touched upon. The main principles of eugenics and their application to social problems are stated in simple but accurate language.

The style is similar to that of "Ask Me Another"—that is, questions are asked and answered. A few typical questions are: (1) Does eugenics have more to do with the improvement of physical or mental traits? (2) Do all physical traits follow the Mendelian law? (3) Are mental traits inherited in the same way as physical traits? (4) Why are many intelligent people more sceptical about the inheritance of mental than of physical traits? (5) But why do children display so many mental traits not evident in either parent? (6) Where do the traits or characteristics of human individuals come from? (7) Which is more important, heredity or environment? There are a total of 371 questions and answers. —C.M.P.

Trafton, Gilbert H., and Smith, Victor C. *Science in Daily Life.* Chicago: J. B. Lippincott Company, 1936. 689 p. $1.26.

Science in Daily Life is a worthy addition to a meritorious list of general science textbooks. The selection of the content is based upon an examination of "45 leading syllabi and courses of study in general science." The material was tested experimentally with many hundred ninth-grade pupils. An attempt has been made throughout to emphasize fundamental scientific principles and their modern practical applications.

Each of the seventeen comprehensive units is divided into specific problems—each with its questions, demonstrations, discussions, summary, and references.

The following seventeen units are included: (1) How Is Air Part of Our Daily Lives? (2) How Do We Use Fire for Heat? (3) How Do Weather and Climate Affect Our Way of Living? (4) How Do We Make and Use Electricity? (5) How Do Machines Do Our Work? (6) How Do We Use Light? (7) How Can Science Improve Our Houses? (8) Transportation after a Century of Progress. (9) Sound and Communication in Daily Life. (10) The Earth in the Universe. (11) The Earth is Our Home. (12) Water in Our Daily Lives. (13) How are Plants and Animals Fitted to Live in Their Surroundings? (14) How Do Plants and Animals Affect Man? (15) Food and the Body at Work. (16) How Can We Safeguard Our Health? (17) How Can We Select and Use Clothing Wisely?

A Teachers' Manual accompanies the textbook.

The senior author, Gilbert H. Trafton, is Professor of Biology of the State Teachers College of Mankato, Minnesota. Mr. Victor C. Smith teaches general science in the Ramsay Junior High School of Minneapolis. —C.M.P.

Tannenbaum, S. A., and Branden, Paul Maerker. *The Patient's Dilemma.* New York: Coward-McCann, Inc., 1935. 278 p. $2.50.

This is a book for the layman. Its subtitle is *A Public Trial of the Medical Profession,* and it is just that. Dr. Tannenbaum is an eminent physician of thirty-seven years' experience, a well-known paleographer. He received the honorary degree of Doctor of Humane Letters from Lehigh University.

The Patient's Dilemma exposes the present situation in medicine and shows the dangerous paths into which many practitioners are forced, and suggests a remedy. Among the common rackets resorted to by mercernary medicos are: the "diagnosis" and "consultation" rackets; the "hospital" and "surgical" rackets; the "baby business" and "psychoanalysis" rackets, the "compensation" and "fee-splitting" rackets, and the one hundred and one additional tricks of "ethical profiteering." The author is opposed to socialized medicine and presents some very excellent arguments against its state-wide adoption. —C.M.P.

Thomson, Sir J. Arthur, *Biology For Every Man.* (2 vols.) New York: E. P. Dutton and Company, Inc., 1935. 1561 p. $5.00.

These volumes represent the final and probably the greatest work of a man who was master of his subject. Technicalities are omitted, but the relation of living things to our everyday life is stressed. It is not a text for the scholar, but it is an authoritative work for the layman, a source of fact material for the teacher, and a work that all can enjoy reading. Volume I includes twenty-one chapters of which the following are samples. What Life Means; Bird's Eye View of the Animal Kingdom; The Simplest Animals; Flat Worms and Round Worms; Insects; Reptiles; and Mammals. Volume II treats in three divisions: animal life in general, the plant world, and man. There are nearly 500 illustrations. —W.G.W.

Sullivan, J. W. N. *The Limitations of Science.* New York: The Viking Press, 1933. 307 p. $2.75.

If you are a dyed-in-the-wool scientist, pigeonholed in a restricted realm and unable to see outside, or uninterested in what may be outside, you will not care to read this book. On the other hand, if you are curious about everything in the world—art, literature, music, reality, and beauty, as well as science *per se*—then you will get much pleasure in reading what Mr. Sullivan has to say about the limitations of science.

He correlates science and aesthetics and shows the excellencies of each and both. His philosophy is evidently, "Not either or, but both and." His wide reading has made it possible for him to give the layman some useful ideas about the expanding universe, the mystery of matter, the web of reason, the scientific account of origins, the nature of mind, and the values of science, as well as the limitations which one must admit it has. But the real scientist is pictured as a true artist. The joy which he has in his work is the joy of an artist.

In this day of correlation and integration, of orientation and survey courses, this book is a welcome addition to the school or college library. —A.W.H.

Bennett, H. *Practical Everyday Chemistry.* Garden City, New York: Garden City Publishing Company, 1934. 305 p. $1.98.

Practical Everyday Chemistry is a book that should be available to every chemistry teacher and every chemistry class. The reviewer believes that this book is the most useful book a chemistry teacher or class could have in addition to the regular textbooks and laboratory manuals. Over 2,000 practical, workable formulas for cosmetics, lotions, pastes, cleaning fluids, flavorings, polishes, and other common necessities are included. Students in the reviewer's classes used it very extensively and were very enthusiastic over the many materials they were able to make, often better than the same material they had been purchasing, and so much cheaper. This is a recommended first supplementary book in chemistry for secondary chemistry classes. —C.M.P.

Hawks, Ellison. *The Book of Natural Wonders.* New York: Loring and Mussey, 1935. 260 p. $2.00.

Changes in the inorganic earth are in many ways comparable to changes in organic living beings. This book pictures many of the changes in the surface of the earth from the remote past to the present. It gives brief but interesting accounts of the earth, a planet; wonders of rocks; erosion; high mountains; earthquakes; volcanoes; geysers; plains; deserts; and the Meteor Crater of Arizona.

It tells of present research and methods of studying the changes of the earth and of interpreting the observed data. The presentation is without technicalities and will interest the junior-high pupil and the retired adult equally. —W.G.W.

Hawkins, Alfred C. *The Book of Minerals.* New York: John Wiley and Sons, 1935. 161 p. $1.50.

This book is written for laymen. It presents in nontechnical language the story of important minerals, many of which furnish man with products in daily use. It avoids most of the technical difficulties of the subject of mineralogy.

Free descriptions of the minerals are given in each case which are followed by specific and scientific details. Excellent photographs of many crystal forms add to the attractiveness of the book. The reviewer believes that teachers of elementary science and junior-high-school science should find this book a helpful reference text. —E.D.H.

Deming, Frank R., and Nerden, Joseph T. *Science in the World of Work:* Volume I, *Applied Mechanics,* 204 p., $1.28; Volume II, *Applied Physical Science,* 277 p. $1.48. New York: McGraw-Hill Book Company, 1936.

These books will be found of great value to teachers of general science and physics. The authors are instructors in one of the Connecticut State Trade Schools. The science material has been effectually applied and illustrated by concrete examples and experiments related directly to the everyday experience of the individual in connection with the physical side of his environment. Many of the experiments are unique and may be set up with simple apparatus. Much has been said about the function of science in developing ability to use the scientific methods of approach to problems. It seems to the reviewer that the method used in the organization of these texts is more likely to produce this desirable outcome as a concomitant than the usual run of science texts. The experimental work, information, guidance questions and study suggestions are woven together in a way that produces a real progression of thinking. Especial attention is

given to the need of having proper controls, and the learner is led carefully and cautiously from specific details to general conclusions.

—O. E. Underhill.

Deming, Frank R., and Nerden, Joseph T. *Teachers Manual for Science in the World of Work.* (Vols. I and II). New York: McGraw-Hill Book Comany, 1936. 47 p. $0.25.

The manual is to accompany the two-volume text, *Science in the World of Work,* by these authors. The first few pages give some excellent suggestions as to methods of procedure. The philosophy set forth and the techniques of teaching described, although designed for the especial needs of a trade school, could be profitably followed to a greater extent than is now the custom in regular junior-high-school science work. Following this introduction are answers to all questions and problems in the texts, numbered to correspond. Complete and detailed blueprints are given for the special pieces of apparatus which have been developed for this course. High schools having shop equipment would find these useful projects. —O. E. Underhill.

Gautier, E. F. *Sahara, The Great Desert.* New York: Columbia University Press, 1935. 264 p. $3.75.

This colorful and interesting story of the great desert is told by perhaps the foremost authority on this subject. It combines a scholarly treatment of the geography and geology of this region with a clearness and charm of description which makes fascinating reading.

The scope of the book is very great. A few incidents here and there may be mentioned. The dependence of desert conditions on previous fluvial forces is of interest, although its present form is one of great stability. The Sahara must have been a desert as remote as Silurian times. The action of the wind in changing desert conditions seems to be less than is perhaps usually thought. The desert is a land, not of no rain, but of infrequent rain. At intervals violent storms yield much rain. This sinks into the ground and finally drains to supply and maintain the permanent reserves. Does this reserve supply contain accumulated water from ancient times? Fossil water so to speak. Gautier brands this as "an amusing, grandiloquent idea" suggestive as an hypothesis but impossible of proof and likely to remain so for a long time.

The typography of the book is very pleasing. The eye is intrigued by the sepia ink used in both type and illustrations. This tone seems exactly in keeping with the desert scene. The illustrations are excellent. —O. E. Underhill.

Rosendahl, C. O., and Butters, F. K. *Trees and Shrubs of Minnesota.* Minneapolis: The University of Minnesota Press, 1929. 385 p. $3.00.

This treatise on the trees and shrubs of Minnesota has been prepared with extraordinary care. While it has been written primarily for the use of amateur botanists, it will also meet the needs of students studying botany in colleges and universities.

The text deals with 47 families, 107 genera, 324 species, 40 varieties, 14 forms and 18 hybrids. A total of 250 species and varieties are illustrated. —E.D.H.

Beauchamp, W. L., and Miller, Harold H. *A Study Book in General Science. Teachers' Edition.* Chicago: Scott, Foresman and Company, 1936. 331 p. $0.80.

This book is designed to accompany *Everyday Problems in Science* by Pieper and Beauchamp. The various blanks are completely filled in for the benefit of the teacher. —O. E. Underhill.

Mank, Helen Gardiner. *Adventures in Thinking.* Chicago: Benj. H. Sanborn Company, 1935. 348 p. $1.00.

This is a workbook in biology. The exercise integrate both laboratory and study type of activities. Designed to be used in conjunction with the regular textbook, it contains many supplementary activities which make for a desirable flexibility. A section of over 80 pages provides objective test material. The author compromises between the two schools of thought regarding the value of pupil drawings in biology laboratory work by providing skeleton drawings, the details of which are to be filled in by the student. This saves the student the time required to make complete drawings, yet requires careful observation in order to complete the details. The organization is based upon *The Living World* a text by the same author, but may be used with any of the usual high-school texts, and to this end has page references to a majority of these texts at the end of each topic. —O. E. Underhill.

Morgan, Alfred. *A First Electrical Book for Boys.* New York: Charles Scribner's Sons, 1935. 205 p. $2.50.

This is an excellent book for elementary-school science. It combines sound information about electricity and its use with specific directions for constructing many devices. The drawings illustrating how the constructions should be made are excellent. The chapter headings are as follows: What Is Electricity and Where Does It Come From, About Magnetism, About Batteries, How Electricity Produces Magnetism, Dots and Dashes, the First Practical Use for Electricity, Electric Bells, Wires, and Something About Electrical Measurements, How Heat Is Produced By Electricity and Electricity Is Made to Obey, How Electricity Transmits Speech, Electric Light, How Electricity Is Generated and the Electric Motor Does Its Work, Induction, One of Electricity's Most Useful Tricks, How Electrical Power Is Made and Distributed, The Electrical System of an Automobile, Sending Messages Through Space, Electrochemistry, A Kit of Tools for the Chemist, Miscellaneous Uses of Electricity. —O. E. Underhill.

Hessler, John C. *Workbook Manual of the First Year of Chemistry.* Chicago: Benj. H. Sanborn and Company, 1934. 330 p.

This is a standard chemistry laboratory manual designed to have the observations and answers to questions written into blank spaces provided. A supplement is provided containing suggestions regarding the adaptation of the experiments to courses in which only a single laboratory period is possible. —O. E. Underhill.

Hessler, John C., and Shoudy, Henry C. *Workbook Manual for First Year Science.* Chicago: Benj. H. Sanborn and Company, 1935. 196 pp.

This is essentially a laboratory manual, designed for first year general science. Each experiment is set up in the general form: Problem, Materials, Method, Observations, Drawings, Conclusions, and Applications. Questions are given with blank lines for writing in the answers. Each unit is followed by a page of objective test questions. References are made to a number of the more widely used texts, although this list does not seem to include any texts since 1933.

Of the twelve units, ten are from the physical sciences. Geological material is covered in one experiment and astronomical material in one "project" of which there are a total of four set apart from the "experiments" which make up the main part of the workbook.

—O. E. Underhill.

Corwin, Walling, and Corwin, Mae Johnson. *Living Things.* Philadelphia: P. Blakiston's Son and Company, 1934. 681 p. $1.68.

This high-school biology opens with three introductory units of general biology, followed by five units on insects. The remainder of the text presents the biology of plants, (twelve units), animals, (twelve units), and human physiology, (fourteen units). The organization follows a rather formal trend, based largely on classification, particularly in the zoological material. However this material is given more completely than in many high-school texts and with a wealth of illustrative material very interestingly presented, considering how much real meat is present. The authors state that much more western material is included than usual, in order to meet the western demand. In the reviewer's opinion this is very desirable from the point of view of those in the east as well as in the west. The animal classification is more completely illustrated with examples of species, classes and orders within the phyla than is usual, and in a way which adds to the readableness and understanding of the material presented.

Each unit, or chapter, is preceded by a few words of vocabulary and about fifteen study questions, and is followed by a page or two of objective test material and a reference list. Great care has been taken in keying the pronunciation of new words. Each main section of the book, of which there are five, is followed by review test material over the whole section. There is a 26-page glossary which gives definition, pronunciation, and page where the word first occurs. —O. E. Underhill.

Dragoo, A. W. and K. L. *General Shop Electricity.* Bloomington, Illinois: McKnight and McKnight, 1936. 63 p. $0.60.

This is a very practical manual which gives detailed instructions for such basic skills as wiring electric bells and lighting circuits, repairing flat-irons, and similar pieces of apparatus. The diagrams showing proper methods of making house wiring insulations are exceptionally fine. Other activities are: making a code practice set, a galvanometer, magnetic motor, crystal radio set, burglar alarm, and experimental transformer.

—O. E. Underhill.

Hopkins, Arthur John. *Alchemy Child of Greek Philosophy.* Columbia University Press, 1934. 255 p. $3.50.

This book leaves the reviewer with the feeling that the alchemists and their work have been misunderstood. Although many rackets were undoubtedly carried on in its name, nevertheless, the "science" of Alchemy represented logical and consistent theoretical approach to the phenomena observed once certain premises were granted. The connection between the Greek philosophy and the basic tenets of alchemical systems of thought is shown clearly and in an interesting manner. The Aristotelian viewpoint with regard to the perfectibility of nature becomes a dominating factor. Great difficulties are present in interpreting early Alchemical writings due to changes in the meanings of words. For example, a mystical interpretation may be given to the use of the words "baptize" whereas the word was a common technical term in both the dyeing industry and practical metal work. The phenomena which Alchemical theory set out to explain probably originated in methods of giving various surface colors to materials with the production of alloys. Changed physical properties naturally would be taken to signify actual change in substance.

The detail with which the thought of the author is illustrated will furnish much material for enriching and enlivening the high-school chemistry course. It would be interesting to try out some of the Alchemical recipes. The last chapter, "The Last Days of Alchemy," makes the transition to the "modern" work of the eighteenth-century chemists.

—O. E. Underhill.

Boulenger, E. G. *Infants of the Zoo.* New York: Oxford University Press, 1934. 155 p. $2.00.

Photographs and discussions describing some of the mammals, birds, reptiles, amphibians and fishes found at the zoo, and their habits are included. Desirable for the intermediate grades.

—Edith M. Selberg.

Boulton, Rudyerd. *Traveling with the Birds.* Chicago: M. A. Donohue and Company, 1933. 64 p. $1.50.

A book on bird migration and excellent for young children. It describes the migratory habits and routes of such birds as the bobolink, cardinal, junco, blue jay, Baltimore oriole, barn swallow, cliff swallow, and many others. The author is associated with the Division of Birds, Field Museum of Natural History. The book, therefore, is commendable because it is written by a trained individual. It is illustrated with photographic plates and black and white sketches of the birds. —Edith M. Selberg.

Watson-Baker, W. *World Beneath the Microscope.* New York: The Studio Publications Inc., 1935. 76 p. $2.50.

Unusual photomicrographs of microscopic organisms and structures. Excellent for revealing the intricate and interesting structural patterns of organisms. —Edith M. Selberg.

Fraser, Chelsea. *Heroes of the Air.* New York: Thomas Y. Crowell Company, 1935. 716 p. $2.50.

One of the books that children of high-school age will enjoy reading. It familiarizes them with the important achievements in aviation from the earliest attempts of man to fly with wings to the flights into the stratosphere. The polar flights and transoceanic flights are pictured, diagrammed and discussed. The outstanding flight achievements for 1935 are included. The book is interestingly written and well organized.
—Edith M. Selberg.

Huey, Edward G. *A Child's Story of the Animal World.* New York: Reynal and Hitchcock, 1935. 355 p. $2.00.

An excellent story illustrating the varieties and kinds of animals. The chapters unfold the whole animal world from the simplest to the most complex, pointing out the gradual evolution and specializations as they occur. Highly commendable for intermediate and junior-high-school students. —Edith M. Selberg.

Huxley, Julian, and Andrade, E. N. da C. *Simple Science.* New York: Harper and Brothers, 1935. 688 p. $3.50.

The book is divided into three parts. The first part includes a discussion of What is Science?, The Nature of Things, Movement and Forces, Energy, Air, Water, and Life. Part two includes Burning and Breathing, How We Move our Bodies, How the Body Machine is Controlled, Heat and Temperature, Human Temperature, How Plants Live and Some Different Ways of Living. Part three discusses Electricity, Magnetism, Organic and Inorganic Chemistry. Recommended for reading in the secondary school.
—Edith M. Selberg.

Fraser, Chelsea. *The Story of Aircraft.* New York: Thomas Y. Crowell Company, 1933. 510 p. $2.50

Part I of the book describes the lighter-than-air crafts used in flying. The evolution of this type of flying is adequately handled together with the practical values of such flying. Part II discusses the heavier-than-air crafts used in notable flights. The use of the airplane in America and foreign lands, gliders and the future of flying is interestingly described. The author describes aerial advertising, photography, and the use of air craft in exploration. The book should be of interest to social studies as well as to science classes. —Edith M. Selberg.

Bradley, John Hodgdon. *Autobiography of Earth.* New York: Coward-McCann, Inc., 1935. 347 p. $3.00.

One of the most interesting and worthwhile books recently published. The language and word pictures used are delightful. It is a description of a translation of the earth's own story, showing the numerous cycles of change. It treats of the erosive work of winds, rivers, and glaciers; of the work of volcanoes and earthquakes; and of the upheaval of mountains. "It treats of the rise of man in the midst of these hostilities; of his search for comfort and self-expression in an indifferent world; of the forces that hold him slave to the earth, and of his struggles to be free. It blends the sages of terrestrial unrest into an informative and thrilling drama whose appeal is for all who are curious about the larger world beyond themselves." —Edith M. Selberg.

Ditmars, Raymond L., and Carter, Helene. *Prehistoric Animals.* Philadelphia: J. B. Lippincott and Company, 1934. 64 p. $2.00.

The book is well illustrated with numerous pictures and maps which show the extinct reptiles, mammal-like reptiles, birds and mammals and their distribution in prehistoric times. Students of the intermediate and junior-high-school grades will enjoy the subject matter and the maps. The maps show the kinds of animal and land forms that existed in the Permian, Triassic, Jurassic, and Cretaceous and Pleistocene periods. Additional maps show the distribution of the tertiary mammals throughout the world, and on the British Isles when that island was a part of the mainland. The material is well written and the vocabulary is very satisfactory for children. Further recommendation is superfluous because the reputation of the author as a scientist is sufficient commendation. —Edith M. Selberg.

Hartmann, Newton H. *Queer Birds.* Philadelphia: Edward Stern and Company, Inc., 1934. 24 p.

The book is desirable for younger children. The photographs of the birds are good-sized pictures and are accompanied by a short paragraph.
—Edith M. Selberg.

Schmidt, Karl Patterson, and Weber, Walter Alois. *Homes and Habits of Wild Animals.* Chicago: M. A. Donohue and Company, 1934. 64 p. $1.50.

The chapters cover Animal Workers, Coats of Hair and Fur, Animal Hunters and Their Prey, Animal Fisherman, Animal Travelers, Furry Playmates, The Family Life of Animals, Strange Animals of North America, and Animal Characters. The animals described in the chapters are illustrated with naturalistic and photographic plates and with animal sketches. The latter are delightful and most interesting from the art standpoint. The book is recommended for young children. The material is authentic. The author is associated with the Field Museum of Natural History in Chicago. —Edith M. Selberg.

Ditmars, Raymond L., and Carter, Helene. *The Book of Zoography.* Philadelphia: J. B. Lippincott and Company. 1934. 62 p. $2.00.

The book, well illustrated and well written, discusses the distribution of animals over the world, their appearance and their habits. An excellent source book for such information. Especially recommended for intermediate and junior-high-school pupils. —Edith M. Selberg.

Snyder, J. Rossiter. *Creatures Great and Small.* New York: Loring and Mussey, 1935. 77 p. $2.00.

The book contains excellent photographs of animals, such as a spider in a web, large animal heads, dancing goat, snails, frogs, insects and many other animals. The author, "once an army officer, now a successful free-lance and syndicate photographer" has taken very remarkable pictures. —Edith M. Selberg.

Roberts, Thomas Sadler. *Two Hundred Ninety-Five American Birds.* Minneapolis: University of Minnesota Press, 1936. $2.00.

A reproduction of the plates of the *Birds of Minnesota* in a convenient ring binder. The book may be opened and laid perfectly flat. For one who cares to identify birds by pictures alone there is no duplicate for these pictures. Valuable for nature study work, especially in the grades. —Ezra C. Harrah.

Sherwood, Noble Pierce. *Immunology.* St. Louis: C. V. Mosby Company, 1936. 608 p. $6.00.

A readable, well printed, clearly written, scientific presentation of the factors involved in immunity. The author has made a scholarly presentation of the latest and most well demonstrated facts of immunology without sacrificing the ease with which the material may be written and understood. The material is divided into twenty-six sections, each one of which is in itself a masterly presentation. The author deals with the principles underlying immunity and the factors involved in producing it as well as the response of the body in fighting disease. The book is illustrated with twenty-four figures and eight colored plates at well chosen points. This should furnish an excellent up-to-date source for colleges and medical schools and a reference book for high schools and teachers. The information presented here is valuable to the lay reader, and one who has a high-school education should be able to read this material with profit. Each chapter is provided with a long list of references, both of textbooks and research papers. It is most highly recommended for those who are interested in bringing their education on immunology up to date. —Ezra C. Harrah.

Moseley, Edwin Lincoln. *Other Worlds.* New York: D. Appleton and Company, 1933. p. 226. $2.00.

This is one of the splendid *New World of Science Series,* edited by Watson Davis. An authority in the field writes with a clarity and simplicity which is as interesting as it is informative. The first six chapters, dealing with meteors, meteorites, shooting stars and comets, is the best popular treatment of these related subjects the reviewer has seen. The next five chapters discuss the moon and planets. The last chapter, Are There Creatures Like Ourselves in Other Worlds, is also related to these five. The major portion of the book is given to the solar system and related problems. Four chapters extending beyond the solar system are: How Knowledge of the Stars Has Been Obtained, Variable Stars, Double and Multiple Stars, and The Universe. —O. E. Underhill.

Wells, H. G., Huxley, Julian S., and Wells, G. P. *The Science of Life.* Garden City: Doubleday, Doran and Company, Inc., 1934. 1514 p. $3.75.

This is a composite of the larger, more expensive work by the same authors, and although a little more difficult to read on account of the print and the character of the paper, the price is very attractive, and it makes another excellent science reference available to many people. This book should find its way into the library of every school. —Ezra C. Harrah.

Roberts, Thomas Sadler. *Bird Portraits in Color.* Minneapolis: University of Minnesota Press, 1934. $3.50.

An excellent set of bird pictures which makes available the excellent plates published in the *Birds of Minnesota* with new text material of an attractive nature. The descriptions are accurate and easily read. The reader need not be confused with scientific names. The names seen are the common names used in most cases.

This book is one that should be available in every school and public library in order that the birds of the region may be known and understood. With the plates and the text one can identify most of the birds of any region. —Ezra C. Harrah.